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THESIS

**A TRAINING TRANSFER STUDY OF THE INDOOR
SIMULATED MARKSMANSHIP TRAINER**

by

William Walter Yates

September 2004

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13. ABSTRACT (maximum 200 words)

This thesis examines the effectiveness of the Indoor Simulated Marksmanship Trainer (ISMT) as a tool to train shooters in the fundamentals of marksmanship. Key concepts explored in the research are verification of skills transfer resulting from practice and the predictive value of simulated performance to proficiency at real task performance. There was no statistical difference in the scores of recruits trained in the ISMT versus a control group that was not trained in the ISMT. Scores on simulated firing were not a strong predictor of live fire performance. In a second experiment subjects were evaluated on their proficiency and improvement during un-coached practice at the task of simulated precision fire on a target at a simulated known distance of 300 yards from the shooters. After comparable amounts of practice in the ISMT, subjects who had not previously received formal marksmanship training failed to demonstrate levels of proficiency comparable to those subjects who had previously received formal marksmanship training in the military. Consequently, the research found no evidence to suggest the ISMT qualifies as a *black box* training apparatus capable of imparting skill through practice without the added presence of expert instruction or an existing knowledge of marksmanship techniques.

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**A TRAINING TRANSFER STUDY OF THE INDOOR SIMULATED
MARKSMANSHIP TRAINER**

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This thesis examines the effectiveness of the Indoor Simulated Marksmanship Trainer (ISMT) as a tool to train shooters in the fundamentals of marksmanship. Key concepts explored in the research are verification of skills transfer resulting from practice and the predictive value of simulated performance to proficiency at real task performance. The results and analysis of two experiments using the ISMT are the basis for the conclusions drawn from the research. In the first experiment, a side by side comparison was conducted to measure the performance of initial entry Marine Corps recruits trained in the ISMT before beginning live fire training with a control group of recruits who were not afforded training in the ISMT. The results of the experiment showed no statistically significant difference in the live fire qualification scores of the two groups. Just as notable, there was no evidence in the results to suggest negative skills transfer had occurred. The scores on simulated firing in the ISMT during *Grass Week* training were found not to be strong predictor of live fire scores. In the second experiment, subjects were evaluated on their proficiency and improvement during un-coached practice at the task of simulated precision fire on a target at a simulated known distance of 300 yards from the shooters. After comparable amounts of practice in the ISMT, subjects who had not previously received formal marksmanship training failed to demonstrate levels of proficiency comparable to those subjects who had previously received formal marksmanship training in the military. Consequently, the research found no evidence to suggest the ISMT qualifies as a *black box*

training apparatus capable of imparting skill through practice without the added presence of expert instruction or an existing knowledge of marksmanship techniques.

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I.   INTRODUCTION

A.   PROBLEM STATEMENT

The United States Marine Corps has increasingly come to rely upon virtual environment trainers, referred to hereafter as VETs, for initial skill acquisition and also sustainment training for its forces. As the presence of VETs has gained acceptance, there continues to be a lack of analytical studies into quantifying the effectiveness of these training systems before they are fielded. Some VETs undergo extensive front end analysis to determine whether they are likely to accomplish their intended purpose while others are accepted as fulfilling a requirement based on the opinions of subject matter experts. These opinions are more qualitative than quantitative in nature. VETs that are employed without undergoing a study to quantify their effectiveness may gain wide acceptance because of face validity. Face validity is an outward appearance of fidelity to task that does not necessarily imply that a measurable transfer of skills to the user is achieved.

> Second, if we regard testing as a rigorous discipline, face validity has little place because it is both atheoretical and usually imprecise. Face validity basically amounts to what Buck (2001) refers to as "faith validity" —— the belief that a test is OK without empirical evidence (Newfield, 2004).

Flight simulators are the most widely recognizable example of a military VET application but the most common application yet fielded by the Marine Corps is the Indoor Simulated Marksmanship Trainer, commonly referred to by its acronym ISMT. The ISMT was accepted by the Marine Corps in

1990 to fulfill the requirement for a virtual environment marksmanship trainer without a detailed quantitative study of its effectiveness. This thesis attempts to provide quantitative assessment of the effectiveness of the ISMT. Such an assessment is necessary to support employment of the ISMT as a training system. This thesis answers the question of whether the ISMT is effective for its originally designed purpose of training Marines to properly aim and fire the M-16A2 service rifle.

B.   MOTIVATION

Training in virtual environments has been an objective of increasing importance to the United States military for the past two decades. VETs address many challenges to maintaining a well trained force within the constraints of ever tighter defense budgets. The earliest applications of VETs sparked the interest of the military because they appeared to offer a mechanism for student aviators to acquire some of the skills of a pilot without placing them in the potentially lethal environment of being at the controls of an aircraft in flight. Reduced training costs also added to the allure of VETs because of potential savings in time, fuel, and ammunition. VETs are attractive as a substitute for live-fire weapons training not only for the ability to train in a non-lethal environment but also because the availability of live-fire training ranges has significantly diminished over recent decades because of the encroachment of civilian communities around military bases. Mr. John Walsh, senior program analyst for training ranges in the office of the deputy undersecretary of defense for readiness, identifies environmental compliance as an increasingly difficult element of the encroachment issue

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that compounds the challenges of training noise and airspace restrictions.

> Walsh identified other environmental issues that impact readiness and combat effectiveness. "We are having conflicts over ammunition associated with what's called UXO [unexploded ordnance], but actually constitute more of the constituent of UXO, and the chemicals that are left over [from a round not being expended] and whether or not they are hazardous wastes. So the traditional encroachments that we had 10 years ago have gotten worse. New encroachments have been added. So what we are finding is that in some places we have some significant problems," Walsh said. (Kauchak, 2002)

Finally, mobile and deployable VETs offer the ability to provide sustainment training to troops embarked upon naval vessels during operational deployments. Embarked units are severely restricted in opportunities to train because deck space is at a premium and firing at reduced silhouette paper targets with the ocean as a backdrop is subject to the effects of weather and conflicting demands of other topside operations while the ship is underway. Even without the cost and scarcity of deck space aboard ship, the conventional marksmanship training conducted aboard ship also lacks realism because of the static nature of the targets and the close ranges.

For all of the reasons listed, a great deal of attention and many millions of defense budget dollars have been spent to develop and deploy VETs throughout the military. The military aviation community is among the largest customers for VETs but they are also employed in such diverse applications as naval damage control, ship handling, marksmanship, naval propulsion mechanics, target acquisition, and surgery. As the use of VETs continues to

grow they are increasingly being viewed as not only an augmentation to conventional training but in some cases as a substitute. The United States Army has recently adopted policy that basic marksmanship qualification will be conducted in the Engagement Skills Trainer, a marksmanship VET similar to the ISMT, in place of live fire training. There are several individual training standards, referred to as ITS, for infantry Marines that are performed only in the ISMT vice in a live-fire environment. If the ISMT is not effective in imparting skill to the trainee, there is an obvious risk to the safety and effectiveness of those trained with the ISMT.

C.   RESEARCH QUESTIONS

This research sets out to answer several questions regarding the ISMT and its employment. Firstly, as it is presently employed to train Marines and recruits, does the use of the ISMT accomplish skill transfer from the virtual training environment to actual proficiency as a marksman? If it accomplishes skill transfer, can it be quantitatively compared to the transfer accomplished by conventional training methods? Even without addressing the tactical aspects of marksmanship, the technical elements include the development of fine perceptual-motor skills that require considerable practice to acquire.

Data gathered to answer the first question leads to a second research question; what are the particular strengths and weaknesses of the ISMT and how can it be most effectively employed?

Finally, does data collected on skills transfer from training in the ISMT support the idea that training in the

ISMT is a satisfactory substitute for live fire marksmanship training.

My basic hypothesis about the effectiveness of the ISMT is that it is an effective training tool for teaching basic marksmanship and that the fidelity to the task of actual live fire shooting is sufficient to be of value as a predictor of live fire performance.

D. ORGANIZATION OF THE THESIS

This thesis is organized in the following chapters:

- Chapter I: Introduction. This chapter gives a general outline of the work and defines the problem addressed by this research.

- Chapter II: Background. This chapter discusses existing research on marksmanship training in both real and virtual environments.

- Chapter III: Methodology of Experiments. This chapter discusses in detail the design of the experiments and the collection of data for the thesis.

- Chapter IV: Results. This chapter discusses the data collected from the experiments and the analysis of it.

- Chapter V: Conclusions. This chapter describes the conclusions drawn from the results of the experiments.

- Chapter VI: Future Work. This chapter discusses questions raised during the thesis and ideas for further research.

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II. BACKGROUND

A. INTRODUCTION

This thesis research examines the application of a VET to fulfill the requirement of a technical marksmanship trainer for the United States Marine Corps. There have been many studies and at least a few texts written on the topic of skills acquisition theory applied to the topic of marksmanship training and also a growing body of research on the effective use of VETs. A discussion of both distinct areas and their overlapping concern follows in the form of a literary review.

B. HISTORICAL PERSPECTIVES ON MARKSMANSHIP TRAINING

Marksmanship training has been one of the fundamental competencies of successful military organizations since projectile weapons replaced edged weapons as the primary tools of the infantry. Archery is a direct antecedent to marksmanship with a firearm and may provide useful historical insight on training methods that are applicable to modern military marksmanship. The development of skill as a marksman or archer requires vast amounts of practice to become truly proficient.

1. Training in the Age of the Longbow

At the beginning of the Hundred Years War, King Edward III focused his attention on creating a great number of skilled archers which he intended to employ against the army of France. Edward began by issuing a decree in 1365 that prohibited on pain of death the practice of all sports except archery and forgave the debts of all craftsmen who made longbows from the wood of the Yew tree (Targeted Tax Breaks, 1999). To encourage the development of skilled

archers Edward decreed that every man between the ages of 12 and 65 should practice archery in their spare time and on holidays and that every man who earned more than £2 a year was required to own a longbow (Bow and Arrow, 2004).

The result of King Edward's campaign to train a corps of effective archers was manifested in his force of archers employed at the Battle of Crecy in 1376. Historical sources estimate that 5,000 English archers were able to launch eight arrows per minute from each of their longbows for an astounding capacity of a 40,000 round per minute volley into the French forces. The result was a crushing defeat of the numerically superior French army of 30,000–40,000 troops due mainly to the archers among the English force of between 12,000–20,000 troops. Prince Louis Napoleon is quoted as commenting on the skill of English archer that "a first rate English archer, who, in a single minute was unable to draw and discharge his bow 12 times, with a range of 240 yards, and who in these twelve shots once missed his man, was very lightly esteemed" (Targeted Tax Breaks, 1999).

2. Expert Marksmanship

The presence of highly skilled marksmen has been the decisive factor in many small unit engagements. The employment of snipers against enemy forces in many cases has a disproportionate impact in a battle. These expert marksmen engage the enemy in a manner that can almost be described as asymmetric because the enemy cannot respond in kind to counter a sniper's attack. Captain Sam Woodfill was awarded the Medal of Honor during World War I for superb employment of his rifle at long range to single handedly defeat five separate enemy machineguns and in the

process killing 21 enemy soldiers with 21 rounds of ammunition (Davis, 1997). In an article describing the action for which Captain Woodfill was recognized Darryl Davis makes the following observation about expert marksmanship in the context of combat.

> Two separate rifle marksmanship communities were present during the war. One was the vast number of those with "equipment familiarity." They "knew" they were getting the best out of the splendid Enfields (M1917) and Springfields. Some had vague knowledge of other individuals who seemed to be able to do magical things, far beyond the ordinary, with the same equipment, but it seemed to be some sort of innate gift, beyond scrutiny. The other community, rifle marksmanship practitioners, never existed outside of a civilian shooting range, and there never was a "community", but only solitary individuals. These underutilized, under-equipped, unorganized, unnamed bearers of the lengthily acquired skills *were never able to explain what it was or that others could become as skilled with practice* (italics added). Those in charge of them never realized that a rifleman with skills is a radically different weapons system with features not the same as those of ordinary riflemen. Rifle marksmanship stayed hidden with the fingers of the practitioners, and has not yet emerged, except into the sniper ghetto. (Davis, 1997)

C. CULTIVATING SKILLED COMBAT MARKSMEN

The ultimate objective of military marksmanship training is to develop skilled shooters that can adapt the fundamentals of marksmanship to the environment of combat. It is so widely accepted within the community of military marksmen that marksmanship is a highly perishable skill, even more so if practiced incorrectly, that it deteriorates without frequent practice. This belief is so commonly held that there has been no major study undertaken to quantify the perishability of the skill. The annual USMC Sergeants

Major Symposium in 2000 addressed an agenda item concerning a review of a recent policy change for annual marksmanship requalification training that had de-emphasized the fundamentals of known distance marksmanship in favor of a compromise between known distance techniques and "field firing" techniques. The consensus of the Sergeants Major was that the new sustainment course should be abandoned because its adoption had resulted in lower proficiency among Marines.

> The new marksmanship sustainment course is a hybrid of fundamental marksmanship training and field firing, and like all half measures, it succeeds at neither goal. Use of the hasty sling leads to poor practices of weapon control. Use of the hit/miss valuation scoring leads less proficient shooters to not analyze their hit placements and not try to improve beyond any hit. The use of the hit/miss valuation leads all shooters to believe that a close shot which doesn't actually strike the target is of no value – something that is not true either on the rifle range or in combat.

During the US involvement in the Vietnam War a study was conducted to assess the marksmanship skill of US Army Soldiers that had recent combat experience. The study was undertaken because anecdotal evidence suggested that the marksmanship skill of U.S. forces in Vietnam was unsatisfactory. The results of the study showed that the Soldiers participating in the study were only able to hit a paper target at 50 meters distance employing their service rifle 25% of the time that a historical record indicates was the norm for flintlock riflemen of the American Revolution (Davis, 2000).

Much has been written about the necessity of training combat marksmen and there has been lively debate within the

military about the value of traditional "known distance" marksmanship practiced in the style of a competitive shooting match. Standard qualification courses present targets at ranges of 200, 300, and 500 yards. However, Staff Sergeant John A. Dailey notes that a U.S. Army study in 1952 found that 87% of infantry riflemen conducted 95% of all combat firing at ranges under 300 yards (Dailey, 2000). Even more interesting is that later studies concluded that the average infantry rifle engagement takes place at a range of 125 yards (Dailey, 2000).

Acknowledging the large body of work on the importance of regular and methodical marksmanship training to acquire and maintain proficiency, the modern military is faced with a dilemma between the cost of marksmanship training and its importance to operational readiness of the forces. Virtual environment trainers appear to offer an answer to the problem of cost and convenience in training marksmen.

D. TRAINING IN A VIRTUAL ENVIRONMENT

Despite how commonly VETs are used there are many fielded VETs for which there has been no detailed study conducted to validate the effectiveness of a VET. Such studies are referred to as verification of skills acquisition (or training transfer). A positive verification of skill acquisition requires a quantified measure of improvement at task performance (Fredriksen & Stark, 1989). To justify the expense of developing and fielding VETs they must be verified to accomplish skill acquisition as well as conventional methods of training or a reduced level of effectiveness must be accepted as a trade-off for reduced cost or increased safety.

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It is a common misunderstanding by some potential consumers of VET technology that a VET is a revolutionary device that must or should accomplish training transfer more rapidly than conventional training methods. Since Edward Thorndike published his seminal work on educational research over 90 years ago there has been debate about whether a certain type of media used in training or education is qualitatively superior to other methods (Thorndike, 1912). A VET can be viewed as simply a different media of instruction (Clark, 1983). Some studies have shown a difference in relative achievement between groups that received training on the same topic using different media, e.g. written instruction compared to graphical instruction (Reiser & Gagne, 1982).

Other studies have suggested that the learning has little to do with the media used and more to do with the methods of instruction (Clark, 1983). That is to say that a three dimensional training virtual environment might not be a superior tool for training to a less sophisticated analog of the task. While the debate over the relevance of media in training has not been resolved, it is likely that the potential for a relationship between media and learning should be viewed as an interaction between cognitive processes and characteristics of the external world. An effective trainer must replicate the actual task to the extent that it results in the same cognitive, perceptual and motor processes as the actual task. A device that achieves rapid training or skills development is certainly worth pursuing but the potential benefits of most existing VETs lie in the ability to conduct training inexpensively, safely, and at the times and places of convenience rather

than tying training to a geographic location. A VET may not be a revolutionary device but it can fill a niche that conventional training methods cannot (Schlager, 1994).

E.   VIRTUAL MARKSMANSHIP

This thesis is concerned specifically with validating the effectiveness of the ISMT (Indoor Simulated Marksmanship Trainer) at training novice shooters in the fundamentals of marksmanship. The ISMT is a VET that employs modified infantry weapons, a video projection system, and a precision sensor controlled by two Microsoft Windows based computers. The ISMT was not the first VET developed for marksmanship training. In the early 1980s the U.S. Army developed the Weaponeer marksmanship trainer and employed it to teach initial entry soldiers the fundamentals of marksmanship (Schendel & Heller, 1985). The Army Research Institute developed the Multipurpose Arcade Combat Simulator (MACS) as a trainer for basic marksmanship at about the same time that Weaponeer was developed (White, Carson, & Wilbourn, 1991). Having evaluated these systems the Marine Corps developed a requirements document for a marksmanship trainer for which the ISMT was eventually procured.

F.   A CASE FOR A PART-TASK TRAINER

The ISMT is classified as a part-task trainer as opposed to a whole-task trainer. The distinction between a part and whole task trainer is related to the degree of overlap between the elements of skill (cognitive, perceptual, and motor) that are required to perform the simulated task compared to the actual task. On initial consideration it might appear that a whole-task trainer would be the preferred solution for a VET but that is not necessarily the case (Wightman & Lintern, 1985). Part task

trainers emphasize realistic modeling of critical elements of task performance rather than modeling all elements of a task in a less realistic manner. To illustrate the distinction consider that while loading rounds into the magazine of a weapon is essential to its operation it is not a sub-task that is worthy of inclusion in a marksmanship trainer because it is simple and easily taught without being incorporated into the features of a marksmanship trainer.

The ISMT is designed to simulate the operation of small arms and provide enhanced feedback to the shooter to aid in improving marksmanship skills. Designing a VET requires that a cognitive and motor task analysis be performed to determine what elements of a task should be simulated and what aspects of a task are ancillary or non-essential to the overall success of performance. The basis for the task analysis used to develop the ISMT is the Individual Training Standards (ITS) for marksmanship contained in the Marine Corps Order MCO 1510.84A Individual Training Standards System. The correct performance of the elements of marksmanship sub-tasks are evaluated for correctness using the criteria established in the Marine Corps reference pamphlet MCRP 3-01A, Rifle Marksmanship. The level of detail described in the ITS for marksmanship is not at the level that would be used in cognitive psychology. Nevertheless, the design of the ISMT does provide an environment in which most of the perceptual-motor tasks can be performed in the same manner as with a real weapon on a live fire range.
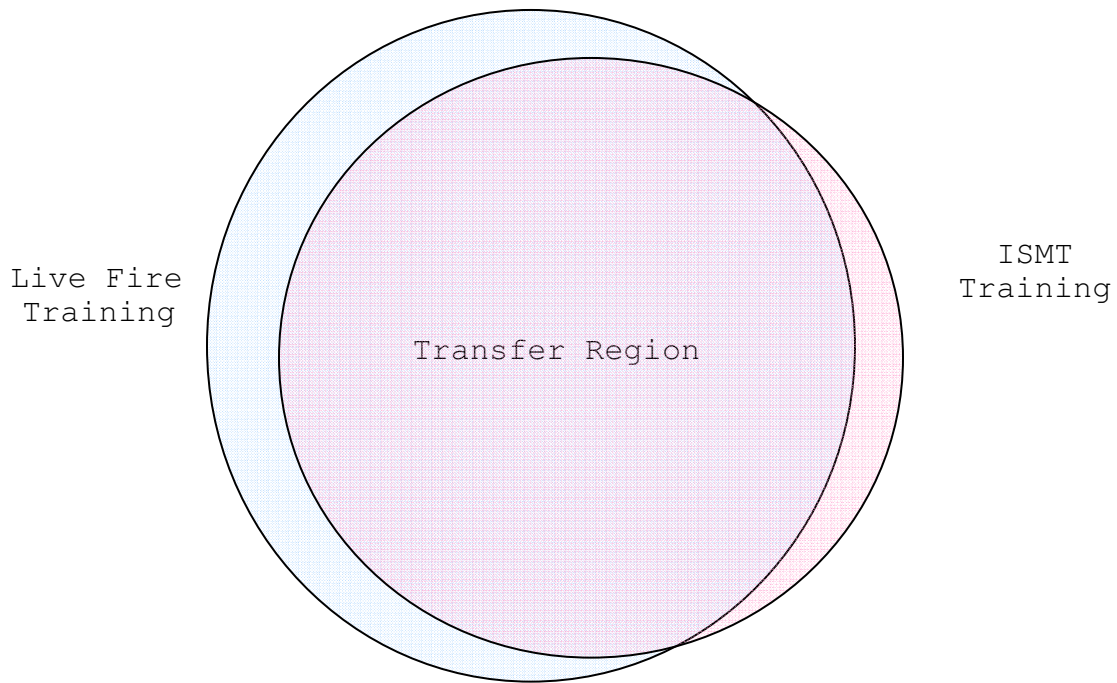
Figure 1.   Elements of Task Performance

In Figure 1 the slightly larger circle on the left
side of the Venn diagram represents the set of all elements
of the task of live fire marksmanship training. The circle
on the right represents the set of all elements of the task
of ISMT training.   The region of overlap represents the
elements of task performance common to both live fire and
ISMT training.   For elements of the task to truly overlap
they must be performed in a manner that is identical for
all practical purposes in both live fire and the ISMT. The
overlap region defines the domain of the sub-task for which
the ISMT serves as a trainer.   The elements of both live
fire and ISMT training that are outside the region of
overlap represent elements of the task that is not common
to the two environments.   The elements in these regions

must be carefully evaluated to ensure they do not result in deficient training on one hand or negative skills transfer on the other.

A transfer of training study similar to what has been undertaken in this thesis for the ISMT was performed on the Weaponeer in 1985 and found it was useful as a predictive tool for performance on a marksmanship qualification course (Schendel & Heller, 1985). The results of this study indicated the scores of trainees on a simulated course of fire using the Weaponeer had a positive correlation to the trainees' scores on the live fire training course. The study of the Weaponeer consisted of three different courses of fire that varied the range and order of presentation of targets to the shooters. The correlation of simulated to actual score on the Weaponeer for a string of 32 rounds of fire to final live fire qualification performance was 0.44. The string of fire consisted of 8 rounds of fire aimed at a target at a simulated distance of 100 meters followed by 24 rounds of fire aimed at a target at a simulated distance of 250 meters. The study of the Weaponeer was concerned primarily with establishing whether performance in a virtual environment marksmanship trainer had predictive value for live fire performance.

In 1991, the MACS was evaluated to determine if it was effective at imparting skill at basic marksmanship in a study at the Air Force Combat Arms School at Lackland Air Force Base, Texas. The results of the study indicated students trained in the MACS performed as well or better than students who were conventionally trained though the difference in performance did not reach the level of statistical significance (White, Carson, & Wilbourn, 1991).

In considering the functionality of a part-task VET for marksmanship there are many aspects to be evaluated relating to the marksmanship learned by conventional means. Performance at marksmanship tasks is affected by some factors for which the military does not specifically address in screening or training. One example of such a factor is contra-lateral hand and eye dominance. The results of a pilot study published in the Journal of the American Optometric Association found that individuals who are right eye/left hand dominant or left eye/right hand dominant scored significantly lower on scored courses of fire compared to shooters who were left hand/left eye or right hand/right eye dominant (Jones, Class, Hester, & Harris, 1996). This finding supported the results of an earlier smaller scale study among ROTC students that also found crossed dextrality to adversely affect the performance of shooters (Sheeran, 1985).

Fatigue is a critical factor in optimal marksmanship performance. Soldiers who were evaluated on shooting accuracy before and after a strenuous road march showed a 26% decrease in the number of target hits and a 33% decrease in accuracy (measured in distance from the center of the target) from those targets that were hit (Knapik, Staab, Bahrke, Reynolds, Vogel & O'Connor, 1991). Sleep deprivation, as distinct from fatigue resulting from strenuous physical activity, has also been show to have a detrimental effect on marksmanship performance (Tharion, Shukitt-Hale & Lieberman, 2003).

In some cases, the corrected visual acuity of shooters effects performance. Recruits who wear corrective lenses may receive government issued glasses at recruit training

with a prescription that is different (for better or worse) than the prescription he or she wore before beginning recruit training. The recruit may not be aware that they have been issued a prescription that is not sufficient to correct their vision to 20/20.

General attributes of weapon design are also relevant to developing skilled marksmen. At the present time all recruits in the Marine Corps are taught to shoot on the M16A2 service rifle but the smaller M4 carbine is used by many units in the Fleet Marine Force and the XM8 carbine presently in development as a replacement for both the M16A2 and the M4 is a smaller weapon. It has been found that performance in scored marksmanship improves when shooters are equipped with weapons having a short stock length (Kemnitz, Johnson, Merullo & Rice, 2001).

Many of the factors contributing to combat marksmanship proficiency cannot be accurately or affordably modeled in a virtual environment trainer. This leads to the theory that decomposing the task into technical training and various tactical training programs is a logical approach. The ISMT has been designed to train aspects of both technical and tactical marksmanship but this thesis will be limited in scope to evaluating its effectiveness at skills transfer of the technical aspects of the task.

III. METHODOLOGY OF EXPERIMENTS

A.   EXPERIMENT WITH INITIAL TRAINING OF NOVICE SHOOTERS

1.   Purpose

The purpose of this experiment is to evaluate and quantify the effectiveness of the ISMT in training novice shooters in the technical operation of the M16A2 service rifle using the *lanes training features* of the system. The question to be addressed is to determine if the ISMT is as effective as conventional marksmanship training given equal training time and supervision to the trainees. The null hypothesis states that there is no statistically significant difference between the performance of subjects trained in the ISMT and those trained by conventional dry-fire techniques. Secondly, this experiment will assess whether task performance in the ISMT is of predictive value with respect to the actual task performance using live ammunition on the Marine Corps' standard known distance course of fire. The null hypothesis states that there is no significant correlation between scored performance in simulated fire and scored performance at live fire.

2.   Subjects

The test and control groups for this experiment will consist of one platoon each of male Marine Corps recruits undergoing initial marksmanship training at Edson Range on Camp Pendleton Marine Corps Base, California. The platoons will be selected at random and their composition is a representative cross section of Marine recruits based upon the attributes of its members. The aggregate characteristics of Marine recruits trained at Camp

Pendleton are as follows. The recruits are drawn from all of the United States west of the Mississippi River. By Marine Corps policy recruits are segregated by sex during initial entry level training. All female recruits are trained at the east coast Marine Corps Recruit Depot, Parris Island SC.

The mental aptitude of the recruits is measured using the Armed Forces Vocational Aptitude Battery (ASVAB). Accession policy mandates that 63% of all recruits must score in the 50th percentile or higher on the ASVAB as compared to the entire population. The remaining 37% of recruits are assessed from the 31st – 49th percentile on the ASVAB. The ASVAB scores of the recruits in the test and control group will not be collected for the purposes of this experiment but the random nature of selection and the sample size of the groups provides a high statistical likelihood that the test and control groups mirror the aggregate mental aptitude characteristics of all Marine recruits.

The educational background of the test and control groups will be recorded in the pre-training questionnaire and should be representative of the aggregate for all Marine recruits. Accession policy requires that 95% of all Marine Corps recruits must possess at least a traditional high school diploma as the minimal educational requirement for enlistment. The remaining 5% of recruits must have completed at least the 10th grade in high school and possess an alternative credential such as a GED certificate. Those recruits permitted to enlist with an alternative credential must also have scored in the 50th percentile or higher on the ASVAB.

The physical size of the recruits participating in the experiment was of peripheral interest because of the potential differences in performance based on their size relative to the M-16A2 rifle. The position of the forward hand on the rifle is a function of the individual's height and arm length. Accession policy requires all male recruits to be at least 62 inches tall and not more than 78 inches tall. Enlistment criteria waivers for height are granted in some instances but the number is a very small percentage of all recruits accessed. It is possible that the effectiveness of the ISMT might be diminished for recruits with longer reach because of the positioning of the telemetry cable on the fore stock of the service rifle simulator (SRS). The position of the telemetry cable may impede the natural positioning of the forward hand on the SRS resulting in an uncomfortable shooting position that detracts from task performance (shooting accuracy). Exploring this possibility is not within the scope of this thesis and is left for future research.

Normal color perception is not considered to be a significant factor in performance in marksmanship but will be recorded as an attribute to be assessed as a possible explanation for outliers in performance.

The subjects' pre-training questionnaire, included in Appendix A, includes a question about whether subjects consumed any caffeine during the course of the experiment. Caffeine consumption has been studied in other research on marksmanship performance (Tharion, Shukitt-Hale, & Lieberman, 2003). It is likely that all subjects in both the test and control groups will not have consumed any coffee or other sources of caffeine in the course of a normal training day. This behavior is likely because of a

policy that prohibits recruits from consuming caffeine or any other stimulant, such as nicotine, during recruit training. While recruits may have been in the habit of consuming caffeine or nicotine prior to beginning recruit training they will have experienced three weeks without any access to these substances prior to participating in the experiment. Withdrawal symptoms from habitual consumption of caffeine or nicotine are assumed to be uniform and insignificant to the performance of the subjects in the study because of the length of the acclimatization period preceding their participation.

Recruits will be asked whether they have ever fired a rifle and, if so, how often and how recently they had fired a rifle. Related questions will record whether the recruits have received any prior formal marksmanship instruction and whether they have ever fired a scored course of fire prior to beginning recruit training. Regardless of prior experience, subjects will be asked to characterize their proficiency as marksmen prior to receiving instruction at recruit training.

3. Standing Operating Procedures

During the normal twelve week course of instruction at Marine Corps recruit training, also referred to as "boot camp," two weeks are spent teaching recruits how to properly shoot the M16A2 service rifle. The program of instruction during these two weeks varies slightly between the recruit depots on the east and west coast. For the purposes of this study all training is based on the standing operating procedures used to train recruits on the west coast. Marksmanship training begins in the fourth week of the twelve weeks of boot camp. The first week of

marksmanship instruction is referred to as "Grass Week" and consists of classes and dry fire training on the weapons. The second week of marksmanship training is referred to a "Qual Week" during which recruits are first exposed to live fire training on the M16A2 service rifle.

The difference in treatments between the test and control groups of this experience is confined to the final two days of Grass Week. In a normal cycle of recruit training the final two days of Grass Week instruction include a combination of classroom instruction and practical application. The application portion of the training is usually a combination of "snapping-in" and simulated firing in the ISMT.

Snapping-in refers to a shooter assuming a proper shooting position and aiming an unloaded rifle at a target. Though unloaded, the weapon is cocked and has a magazine inserted. The target at which the recruit aims is typically as small black silhouette of an actual target that is painted on the side of a white 55 gallon drum. As the recruit attains proper sight picture, sight alignment, natural point of aim, and breathing control, he smoothly squeezes the trigger until the hammer falls on to the firing pin of the weapon. The actuation of the trigger without any ammunition being loaded in the weapon is referred to as "dry-firing." As the recruits snap-in they are observed by trained marksmanship coaches. Snapping does not provide quantified feedback to the coach shooter on the shooter's performance. The coaches may observe improper procedures and provide corrective instruction but they are unable to objectively measure whether the practicing recruit would indeed have hit the target if he were firing live ammunition. The lack of accurate

quantifiable feedback is the major deficiency of conventional training by snapping-in.

The amount of time spent training in the ISMT is at the discretion of the Primary Marksmanship Instructor (PMI) conducting the training. This varies from platoon to platoon. Typically, most of the recruits' exposure to the ISMT is on the final Friday afternoon of Grass Week and may last for three hours. Prior to the adoption of the ISMT, all practical application training during Grass Week consisted of snapping in.

Simulated firing in the ISMT provides the shooter with almost immediate round to round feedback on performance. The feedback consists of several graphical displays task performance. The most basic feedback is the computed point of impact of the recruit's simulated round fired. The ISMT is capable of accurately displaying the point of aim to a precision of two minutes of angle. At the distance of approximately 240 inches from the muzzle of the SRS (and the hit sensor camera) to the projection screen, the point of impact is accurate to a distance of approximately 0.14 inches [sin (2/60) * 240" == 0.1396"] on the projection screen which is slightly larger than one half of a 5.56mm bullet's diameter. In addition to displaying the projected point of impact the ISMT can replay a real time trace of the shooter's point of aim prior to the instant the SRS is fired and also in the seconds after the weapon is fired during the recoil motion. The aim point trace along with the graphical representations of barrel cant angle, butt pressure, and trigger pressure are used to analyze the performance and correct technical deficiencies in the shooter's actions.

4.   Controlled Parameters

a.   *Time Allotted to Training*

The modified program of instruction for the control group deviated from the normal training by excluding the subjects from any exposure to training in the ISMT during Grass Week. That is to say, the recruits in the control group were trained in the manner that all recruits were trained prior to the adoption of the ISMT and had no knowledge of the ISMT. The program of instruction for the test group provided the subjects as much exposure to simulated firing in the ISMT as possible during the final two days of Grass Week. The total training time in the ISMT for the test platoon was approximately nine hours.

b.   *Instructor Proficiency*

The proficiency of the PMI conducting the training was considered to be a significant factor in the performance of recruits. The influence of a particular marksmanship instructor upon the performance of his students has not been assessed in a quantitative study although the officer in charge of training at Edson Range expressed a belief that the same instructor should be employed to train both the test and control groups. To account for the possibly confounding variable of instructor proficiency the same PMI was used to conduct the training of both the test and control group. The PMI selected to instruct the subjects in this experiment was recognized for professional achievement as the outstanding PMI on the staff at Edson Range for the most recent quarter of the calendar year preceding the experiment.

c.   *Equipment Calibration*

The ISMT used for the training at Edson Range is maintained on a daily basis by the staff of Marksmanship Training Unit. The contractor for the ISMT, Firearms Training Systems Inc, has a representative located at Camp Pendleton that provides technical support and operator training for all of the ISMTs on the Camp Pendleton base where Edson Range is located. On the day prior to the commencement of ISMT training for the test group, the FATS Inc representative visited Edson Range to inspect the system and supervise a calibration of the ISMT. The calibration includes verification of correct spotting of impacts on the projection screen by the hit camera. The ISMT used to train the test subjects was verified to be in proper operating condition at the time of the experiment.

5.   Confounding Variables

The decision to use the same instructor for both the test and control groups necessitated a compromise and the introduction of a confounding variable into the experiment. A single PMI can only train one platoon at a time. The typical rotation of instructional duties between PMIs at Edson Range includes a week of down time between training platoons of recruits. This procedure resulted in three weeks passing between the live fire qualification training of the control group and the test group. I considered the possibility before beginning the experiment that this passage of three weeks between the outdoor qualifications of the two groups might result in collecting data under significantly different weather conditions. Variations in weather conditions are commonly accepted as having an impact on the performance of shooters.

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Weather may be a significant factor influencing a shooter's qualification score if there are extremes of wind, temperature, or precipitation that adversely affect the shooters' concentration and ability to make accurate windage adjustments. The seasonally normal weather at Edson Range during late February is mild with an average high temperature between 60-70 degrees Fahrenheit with no precipitation. The weather conditions during the live fire training for the control group were within expected norms. During the week that the test group conducted live fire training the local weather conditions at Edson Range included significant wind gusts, precipitation, and an estimated thirty degrees Fahrenheit of temperature change between the commencement of firing in the morning and completion of the course of fire. The range officer noted in his letter of transmittal of the qualification scores that the temperature change and wind on qualification day for the test group were of significant magnitude that it was likely to have had an impact on the performance of the shooters.

The ISMT at Edson Range is capable of training 18 recruits firing on the simulator while another 18 recruits observe the control screen and receive the benefit of the PMI's analysis of the shooters' performance. The training value of the ISMT is assumed to be derived from both individual performance of simulated fire and also from observing others perform simulated fire and receiving the instructor's expert analysis of performance during simulated fire. Therefore, it is considered for the purposes of this experiment that the Edson Range ISMT facility supports the training of 36 individuals simultaneously.

While 36 recruits from the test group received training on the ISMT, the remaining group of approximately 14 recruits was either latent or receiving supplemental snap-in training from a separate instructor. The number of personnel employed to train the test and control groups will be held constant to eliminate the possible effects of a lower student to teacher ratio that might detract from the validity of the experiment's results. It should be obvious that in comparing two methods of training that the number of instructional personnel required to conduct training should be the same lest the effect of more concentrated human resources be confused with a more effective training device.

At the conclusion of training in the ISMT on the final day of Grass Week, 36 of the 55 recruits in the test group were evaluated on a full simulated course of fire that is identical in timing and presentation to the actual live fire rifle qualification course that they would complete the following week. The scores of this simulated course of fire are the first experimental data collected on the test group.

The training of the test and control groups during Qual Week will be identical. At the end of Qual Week all Marine Recruits fire their weapons for official qualification score. The qualification scores of the test and control groups were recorded as experimental data to be analyzed against each other.

B.   PERFORMANCE TRENDS FOR ISMT SPECIFIC TRAINING

1.   Purpose

If training on the ISMT results in measurable positive skills transfer to live fire marksmanship, the question arises as to whether the skills transfer results from

practice of drills on the ISMT alone or from an interaction between the practice of drills and coaching from a PMI. There is an allure to the idea that the ISMT is a self contained trainer that is capable of imparting skill without the presence or input of skilled marksmanship instructors. A precedent that might be used to support the self contained trainer idea is that players commercial off the shelf (COTS) video games demonstrate improvement through practice without the supplementary assistance of a coach or prior instruction to establish a base of cognitive understanding about the video game. This experiment attempts to provide insight on the acquisition of skill imparted through training on the ISMT without the presence of skilled coaches. The null hypothesis states that un-coached practice in the ISMT does not result in increased proficiency evidenced by progressively smaller diameters for shot groups.

2. Subjects

The subjects in this experiment were drawn from volunteers who were from both military and civilian backgrounds. Subjects included military officers assigned as students at the Naval Postgraduate School in Monterey, CA, civilian employees at the Naval Postgraduate School, and civilians with no affiliation to the DOD. The previous marksmanship experience of the subjects ranged from a competitive shooter who was a member of the NPS rifle team to civilians who had never fired a weapon. Some of the subjects have previously fired on the ISMT in the course of their military careers but most had never used the trainer before.

3. **Conditions and Procedures**

   a. *Course of Fire*

   The task performed and measured by the subjects was to fire a trial consisting of three strings of fire from the service rifle simulator at a "D modified" target silhouette. The simulated range of the target projected on the screen was 300 yards and the target was exposed for a period of 30 seconds for each string of fire. After each string of fire, the diameter of the shot grouping measured to the nearest tenth centimeter was recorded. The first two strings of fire consisted of three rounds each and the third string consisted of four rounds. The farthest outlying round from the shot group of the third string of each trial was discarded and the diameter of the three closest rounds was recorded. The mean diameter of the three strings of fire was recorded as the result of each trial. The decision to drop the outlying round of the third string of each trial was made for the sake of averaging three like terms and also to compensate for the fact that although four rounds were fired during the third string, no additional time of exposure was allowed beyond the 30 seconds for the first two strings of fire.

   The training event provided in the ISMT's software used to collect data for this experiment was from the lanes training menu, entry level qualification, day one, zeroing event. The subjects were not evaluated on the accuracy of the mean point of aim for their shot groups. The only variable being measured was the consistency of their aim as measured by the average diameter of their shot groupings. I chose to use the shot group diameter as the metric for this experiment because the ISMT cannot

accurately replicate the effects of adjustments made to the front or rear sight for elevation. ISMT compensates for this with a software feature called "Auto Zero" adjusts the mean point of impact for a string of fire to the center of the aim-point. Rather than introduce the artificiality of the Auto-Zero into the scoring the simple group diameter was selected as the metric.

b. Instructions to Subjects

The subjects in this experiment were briefed on the cycle of operation of the service rifle, fundamentals of good shooting position, proper weapon support, proper sight picture, proper sight alignment, control of trigger squeeze, and breathing control. The guidance was in the form of a verbal in-brief drawn from the MCRP 3-01A. Detailed instruction such as would be provided by a Primary Marksmanship Instructor was not provided because the intent of the experiment is to evaluate the acquisition of skill due to repetitive practice.

c. Potentially Influential Factors

Data was collected from subjects in sessions that ranged from one to three trials. The number of trials per session and the number of session depended on the amount of time the subject was available. A conscious decision was made to limit the number of trials per session to not more than three. This decision was based on the desire to collect data from an environment that resembles as closely as possible the environment in which the ISMT is employed in the Fleet Marine Force. It would be unusual for Marines to be availed of more than an hour of continuous training time on the ISMT in a training day. Research on skills transfer of "blocked practice" versus "random practice" has shown that retention of skill is in most cases improved

with random practice (Proctor & Dutta, 1995). Subjects trained at a task using concentrated blocks of practice performed better *during* the acquisition of the skill but retained less of the proficiency *over time* than subjects who practiced the task for the same total amount of time broken up into several shorter practice sessions. Research on skills transfer of "blocked practice" versus "random practice" has shown that retention of skill is in most cases improved with random practice (Proctor & Dutta, 1995). Subjects trained at a task using concentrated blocks of practice performed better *during* the acquisition of the skill but retained less of the proficiency *over time* than subjects who practiced the task for the same total amount of time broken up into several shorter practice sessions (Shea & Morgan, 1979). The distribution of training with intervals ranging from days to weeks between sessions introduces the possibility that performance trends in individual learning curves within separate sessions will be identified. That is to say, a subject will show improvement within a series of trials conducted on a single day but upon beginning a new session on a different day will perform at a lower level than that at which the previous session finished.

d. *Protocol for Data Collection*

After a subject completed firing a string of fire, the operator of the ISMT would display feedback on the projection screen for the subject using the ISMT's analysis functions. The feedback provided to the subjects was primarily in the form of spotting of the points of impact for the rounds and a color coded trace of the point of aim during the period beginning 0.9 seconds before the round is fired and ending 0.3 seconds after the round is

fired.   The spotting of rounds and the replay of the aim point trace is on a target that appears at a simulated distance of about 10 yards.   The ISMT plots the trace of the aim point for the interval from 0.9 seconds before the round is fired until 0.3 seconds before the round is fired in green.   The trace for the interval from 0.3 seconds before the round is fired until the moment that the hammer falls is plotted in magenta.   The point of impact for the round is depicted on the screen by a red crosshair.   The trace of the aim point during the recoil of the weapon is plotted in cyan.   The aim point trace was replayed sequentially for each round fired.   The replay of the aim point trace is at approximately twice real time, i.e., the 1.8 seconds of actual fire takes approximately 3.6 seconds of playback time.

Each subject was briefed on the significance of the plotted aim point trace during the three periods.   The first phase is useful in approximating the barrel movement as the subject aims at the target as the final trigger squeeze is begun.   The second phase of the plot provides an indication of how smoothly the trigger is squeezed.   The final phase of the plot indicates whether the movement of the barrel during recoils is consistent and controlled or whether the Barrel moves excessively or randomly from round to round.   Subjects were told that minimal barrel movement was desirable, especially during the final 0.3 seconds before the weapon is fired.   Minimal barrel movement is indicated by a short length of aim point trace plotted on the screen or a trace that is confined to a relatively small area on the screen.

e. *Criteria for Rejection of Data*

During the collection of data for this experiment several circumstances arose requiring the establishment of a convention on how data was recorded. From time to time a shooter would not fire the third round in a string of fire because the presentation period of 30 second ended before the last round was fired. In this case, the string of fire was repeated without providing feedback on the subject's performance on the partially completed string. When a subject failed to fire the fourth round during the third string of fire in a trial the trial was recorded with the diameter of the group consisting of the three rounds that were fired. On some trials the ISMT would record a point of impact for a round that was obviously erroneous because of extraneous light sources impacting on the projection screen and detected by the hit camera. In these cases and all others where a string of fire was incomplete as a result of a malfunction in the ISMT, the string was repeated. Each trial recorded on a subject included the mean diameter, the number of trials completed by that subject, and the date that the trial was conducted.

IV. RESULTS

A. EXPERIMENT WITH NOVICE SHOOTERS

The data collected from the novice shooters consists of profile information from the subject questionnaire and qualification scores from live and virtual courses of fire. The subject questionnaire is included in Appendix A. The questionnaire was intended to capture information on the subjects that might have been useful in analyzing the performance of outlying data points in the subjects' performance on live fire qualification scores. Some information relating to the conduct of the experiment was provided by the staff of the Marksmanship Training Unit contained in a letter of transmittal of the data and also informal comments written on the data collection forms by the primary marksmanship instructors.

1. Control Group Data

a. Performance

Figure 2 is a scatter plot of the live fire performance of the subjects in the control group. The X axis of the graph is the subject ID number which was assigned based on an alphabetic ordering of the subjects by last name. The Y axis of the graph represents the qualification point score.
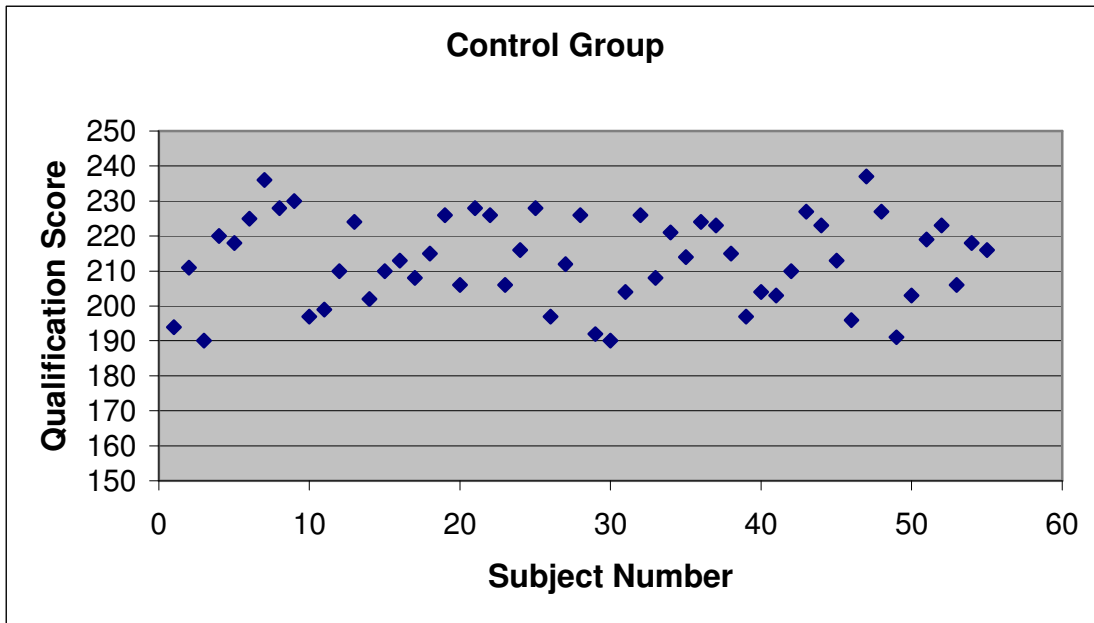
Figure 2.   Control Group Qualification Scores

b.   Demographics

Figure 3 is a graph of the ages of the control group subjects with subject ID number on the X axis and age on the Y axis. The subjects in the control group ranged from 18 to 28 years with the average being 21 years.
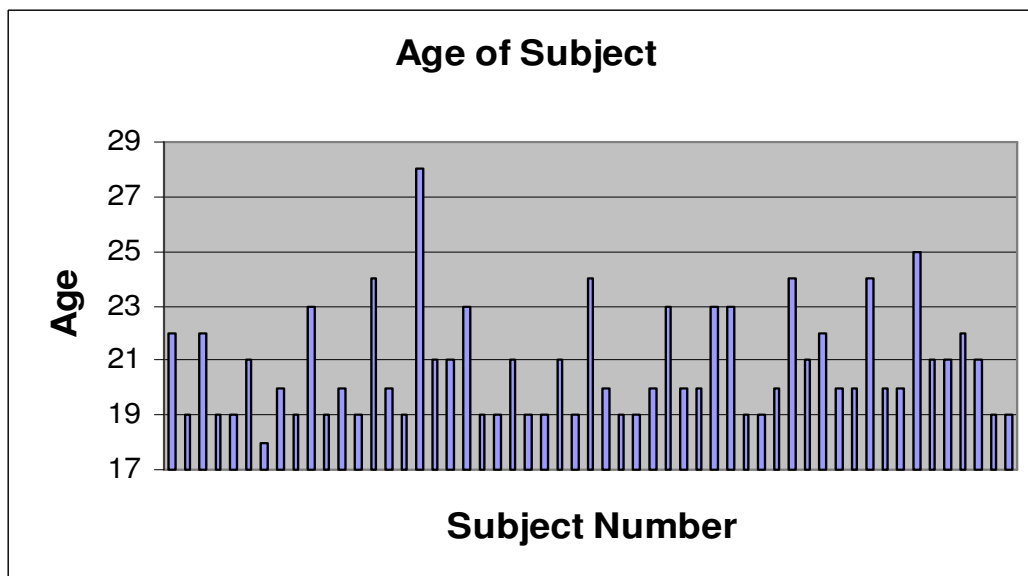
Figure 3.   Control Group Ages

Educational credentials ranged from one subject who held a GED to several who had completed some college level coursework. The Y axis of Figure 4 signifies the highest educational credential held by a subject with a value of 1 corresponding to a GED, a value of 2 corresponding to a traditional high school diploma, a value of 3 corresponding to some undergraduate coursework but short of a degree, and a value of 4 corresponding to a baccalaureate degree. The educational level of the subjects in the control group is typical of the overall educational profile for initial entry recruits. Marine Corps accessions policy is that 95% of initial entry recruits will hold at least a traditional high school diploma.
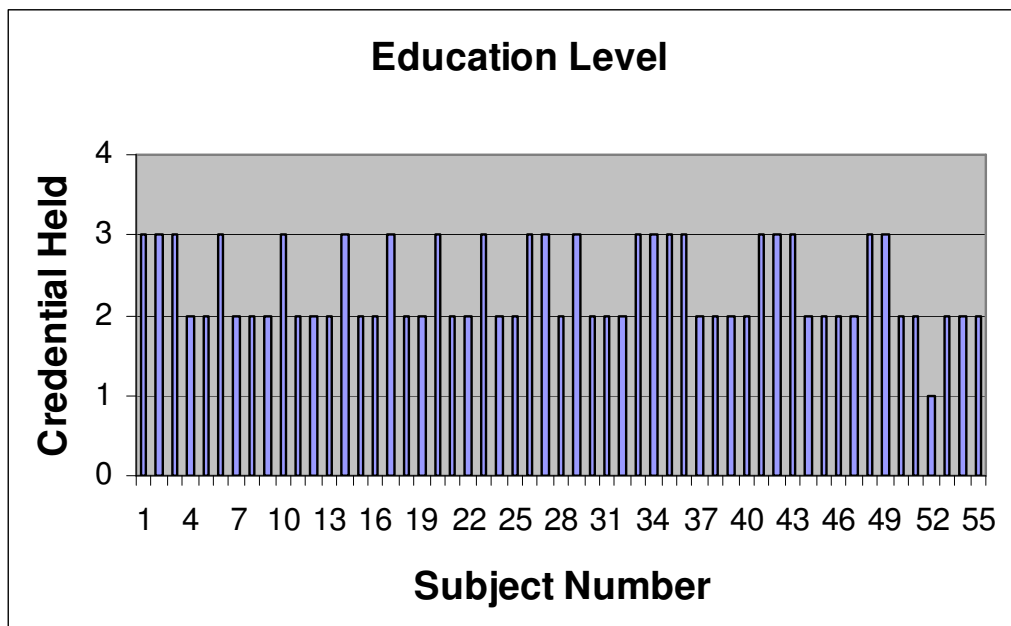
Figure 4.   Control Group Education Credentials

Ninety-two percent of the subjects in the control group had normal color vision. The subjects ranged in height from 62 inches to 78 inches with an average height

of 70 inches. Their weights were within the standards prescribed by the Marine Corps for recruits based upon their individual height.

c.   Marksmanship Experience

Fifty-six percent of the subjects in the control group reported they had fired a firearm at least once prior to arriving at Marine Corps Recruit Training but only 5% reported they had received any formal instruction in marksmanship. Seven percent of those who reported having fired a firearm said they had been scored on some type of evaluated course of fire. The subjects in the control group subjectively rated their own proficiency as marksmen prior to recruit training as follows. Table 1 is a summary of the subjects' self assessments of their proficiency.

Response	Number in Response Category
No answer	1
No experience	31
Some experience but a poor marksman	12
Proficient marksman	11
Very proficient marksman	0

Table 1.   Control Group Self Assessed Proficiency

2.   Test Group Data

a.   Performance

Figure 5 is a plot of the live fire performance of the subjects in the test group. The X axis of the graph is the subject ID number which was assigned based on an alphabetic ordering of the subjects by last name. The Y axis of the graph represents the qualification point score. Figure 6 is an identically configured plot of the test group's scores for the simulated course of fire conducted in the ISMT.
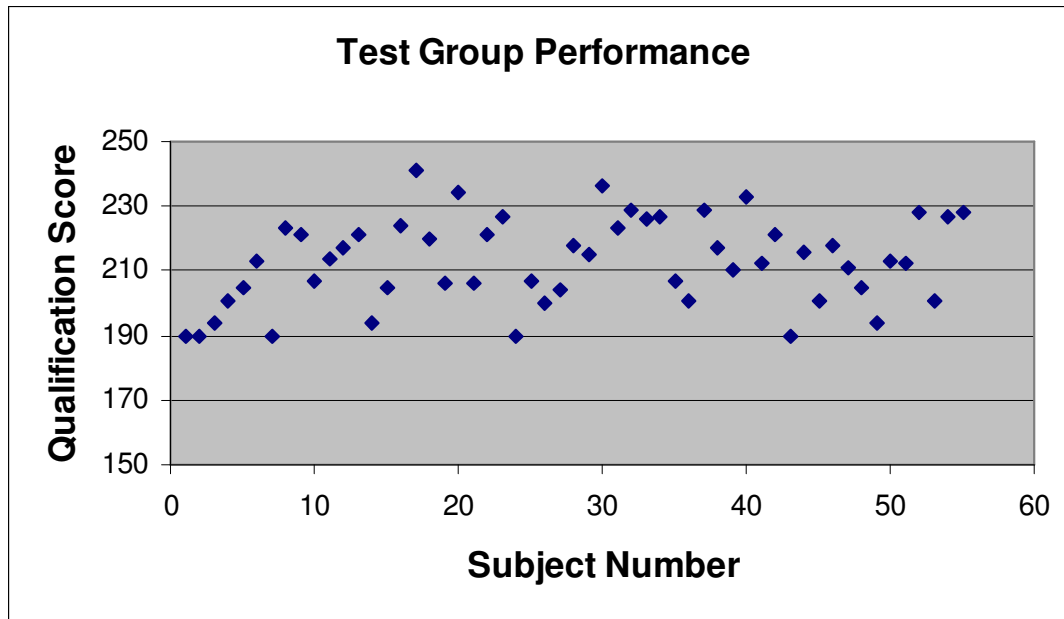
Figure 5.   Test Group Qualification Scores

        Figure 6 is a plot of the subjects' performance
on the simulated course of fire in the ISMT conducted on
the final day of Grass Week.
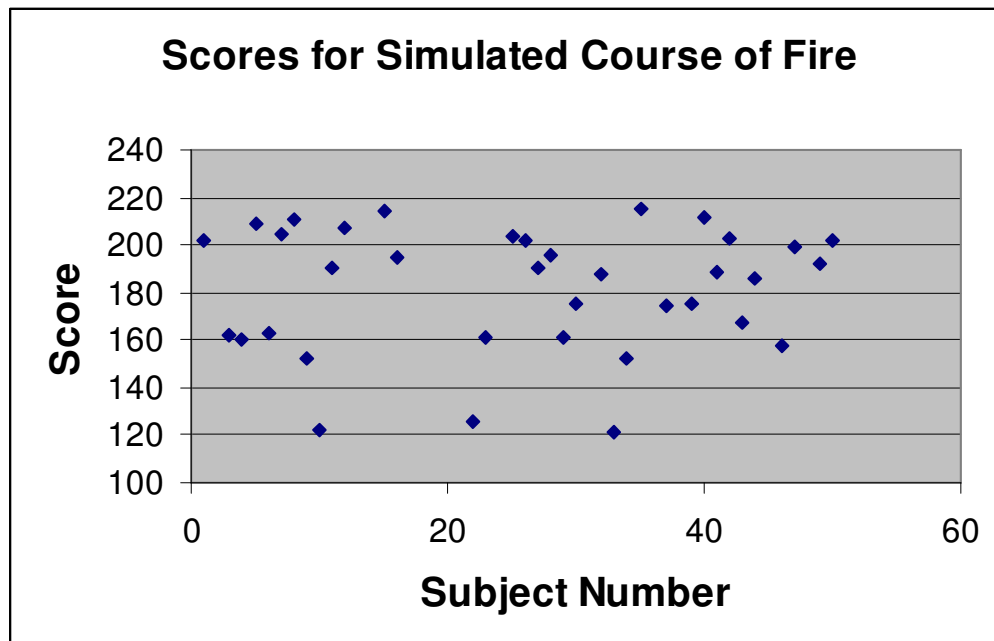
Figure 6.   Test Group Simulated Course of Fire Scores

b.   Demographics

Figure 7 is a graph of the test group subjects' ages with the subject ID on the X axis and age on the Y axis. The ages of the recruits ranged from 18 to 28 years with the average being 20 years.
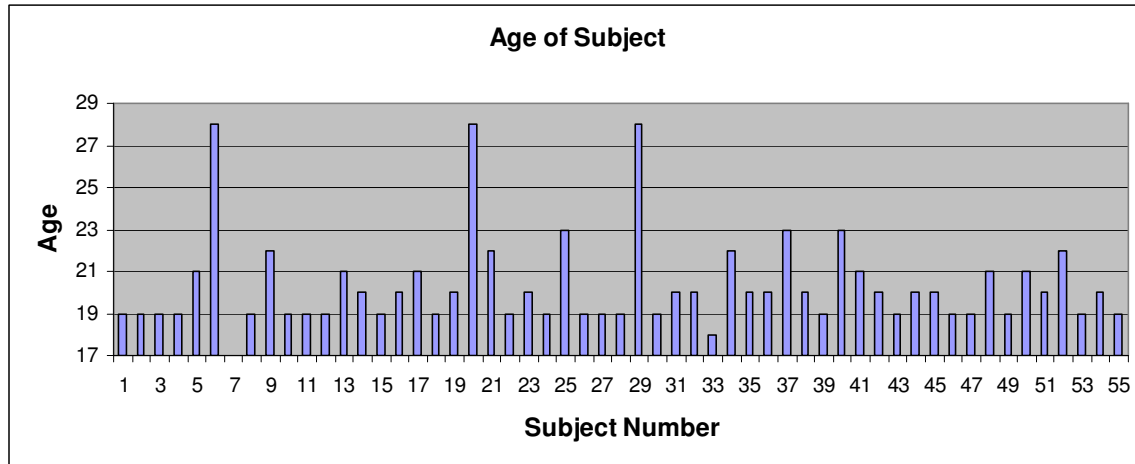

Figure 7.   Test Group Ages

Figure 8 is a graph of the test group subjects' educational credentials with the subject ID on the X axis and education level on the Y axis. Educational credentials ranged from three subjects who held a GED to one who had completed a baccalaureate degree. As with Figure 4, the Y axis of Figure 8 signifies the highest educational credential held by a subject.
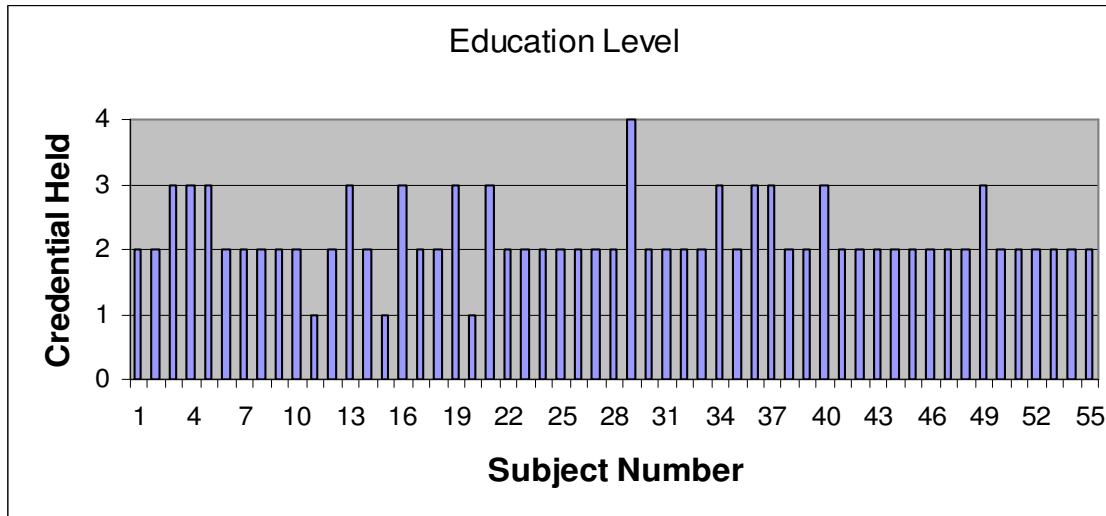
Figure 8.   Test Group Education Credentials

        Ninety-eight percent of the subjects in the test group had normal color vision. The subjects ranged in height from 63 inches to 80 inches with an average height of 70 inches. Their weights were within the standards prescribed by the Marine Corps for recruits based upon their individual height.

c.   *Marksmanship Experience*

        Sixty-nine percent of the subjects in the control group reported they had fired a firearm at least once prior to arriving at Marine Corps Recruit Training and 11% reported they had received some formal instruction in marksmanship. Eleven percent of those who reported having fired a firearm also said they had been scored on some type of evaluated course of fire. The subjects in the test group subjectively rated their own proficiency as marksmen prior to recruit training as follows. Similar to Table 1, Table 2 is a summary of the test group subjects' self assessment of marksmanship proficiency.

No answer	1
No experience	17
Some experience but a poor marksman	16
Proficient marksman	19
Very proficient marksman	2

Table 2.   Test Group Self Assessed Proficiency

B.   GROUPING EXPERIMENT

Data was collected on 26 subjects in the experiment on performance improvement at shot grouping. For the purposes of fitting a linear regression model for the number of practice trials as a predictor of shot group diameter, six trials was considered to be the minimum number of trials to fit a valid model. Of those 28 subjects, 13 subjects completed at least seven trials. The remaining 15 subjects completed four or fewer trials. Figure 9 is a graph of the mean group diameter for each subject. The letter "U" or "T" above each bar signifies whether that subject was a trained or untrained shooter. The red error bar denotes the number of trials from which the mean diameter was calculated.
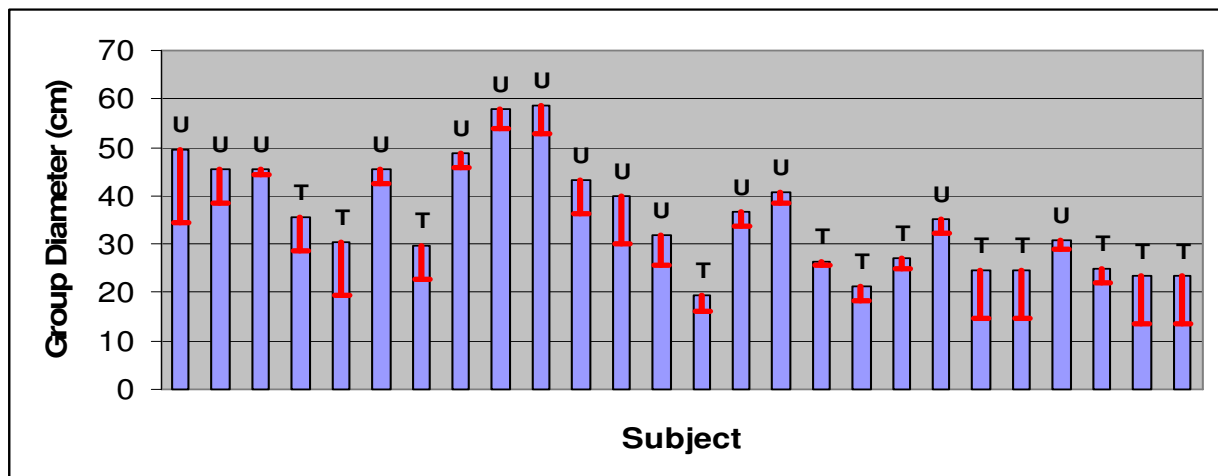
Figure 9.   Average Shot Group Diameters

Table 3 lists the subjects by arbitrarily assigned subject number. The subjects are categorized as "trained" or "other" based on whether they have had prior formal marksmanship instruction. The "trained" subjects consisted of students at the Naval Postgraduate School who were either Marines Corps Officers or Army Officers from the infantry community.

Subject	Category	Trials Completed	Mean Diameter
1	Untrained	15	49.55
2	Untrained	7	45.61
3	Untrained	1	45.43
4	Trained	7	35.46
5	Trained	11	30.49
6	Untrained	3	45.51
7	Trained	7	29.80
8	Untrained	3	48.79
9	Untrained	4	57.94
10	Untrained	6	58.66
11	Untrained	7	43.42
12	Untrained	10	39.96
13	Untrained	6	31.76
14	Untrained	0	N/A
15	Untrained	0	N/A
16	Trained	3	19.27
17	Untrained	3	36.81
18	Untrained	2	40.52
19	Trained	1	26.53
20	Trained	3	21.43
21	Trained	2	27.02
22	Untrained	3	35.27
23	Trained	10	24.53
24	Trained	10	24.72
25	Untrained	2	30.88
26	Trained	3	24.83
27	Trained	10	23.47
28	Trained	10	23.56

Table 3.   Mean Grouping Diameters by Subject

Scatter plots of the average diameters and linear regression models for each subject who fired at least seven trials are included in Appendix B.

V. ANALYSIS AND RECOMMENDATIONS

A. COMPARISON OF QUALIFICATION SCORES

As noted in the methodology of this experiment, difference in the weather conditions present on live fire qualification day for the test and control group are a confounding variable. The Chief Range Officer supervising the training of the test and control group commented upon the impact of weather in his letter of transmittal of the data. He stated the following.

> It is immediately apparent that the test group did not have as good of an initial qualification rate as the control group, and that could lead to a conclusion that the ISMT is not effective. Information that must be used when evaluating this data must include the fact that the control group fired for five straight days in ideal shooting conditions, sunny, with light winds. The test group had two days of good conditions that mirrored the control group, but the Wednesday of firing week was very windy, and a storm front was moving in, dropping temperatures considerably. The Thursday prior to qualification day was rainy, windy, and cold, and qualification day started out with light rain, but gradually improved.

> As an experienced competitive shooter and a professional marksmanship trainer, it is my opinion that the weather experienced by the test group had a significant negative impact on their performance.

In view of the comments of the Chief range officer it would be desirable to duplicate the experiment with both the test and control groups firing for qualification on the same day so as to eliminate the confounding variable of weather conditions. Unfortunately, time constraints and

the logistics of repeating the experiment prevented the duplication of the experiment while controlling for weather.

The summary statistics of the test and control groups are very close in almost every measure. Figure 9 is a box plot of comparison of the test and control groups.

Box Plots
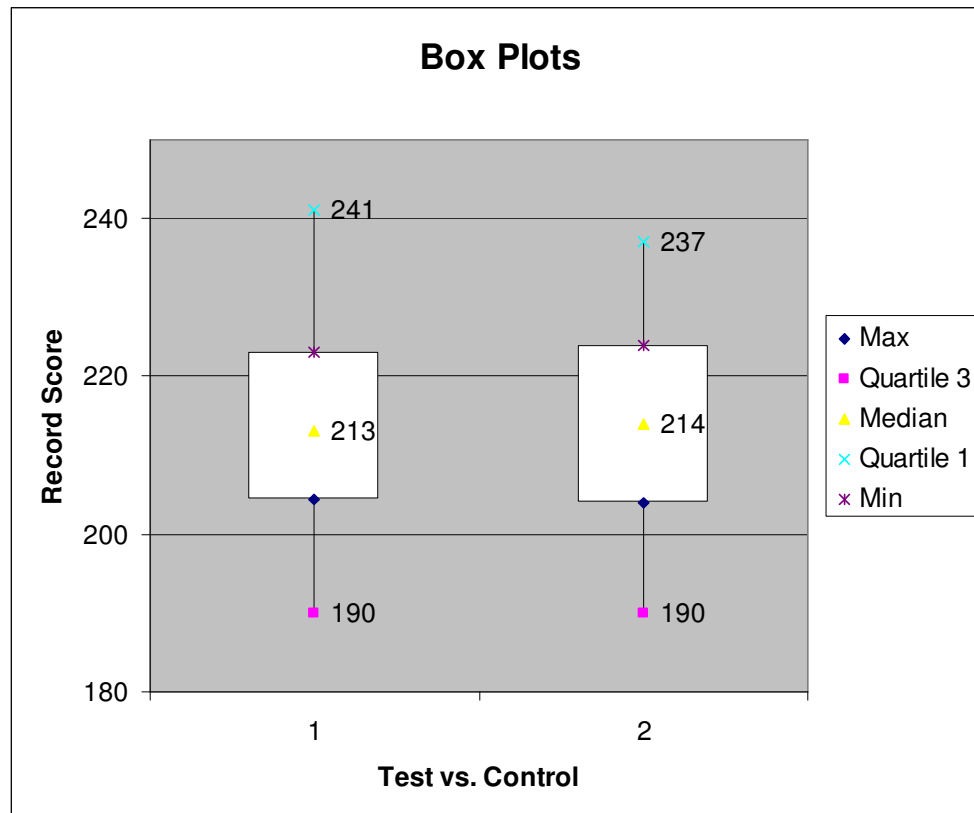
Figure 10.   Summary Statistics

The qualification standards for the Marine Corps known distance course of fire at recruit training are a minimum score of 190 out of 250 possible points. Qualifying shooters are divided into ranked classifications as Marksmen (190-209), Sharpshooters (210-219), and Experts (220-250). It should be noted that while the distribution among the three classifications appears to be bimodal for both the test and control groups, this is actually not the

case as the range of scores for the classification as Sharpshooter is more narrow than the ranges for Marksman and Expert. A histogram of the data for each group appears in Figure 11 and Figure 12. The X axis represents a partitioning of the points scored and the Y axis represents the number of subjects who tallied a score between the given partitions.

Figure 11.   Distribution of Test Group Record Scores

Figure 12.   Distribution of Control Group Record Scores

Table 4 summarizes the performance of the test and control groups.

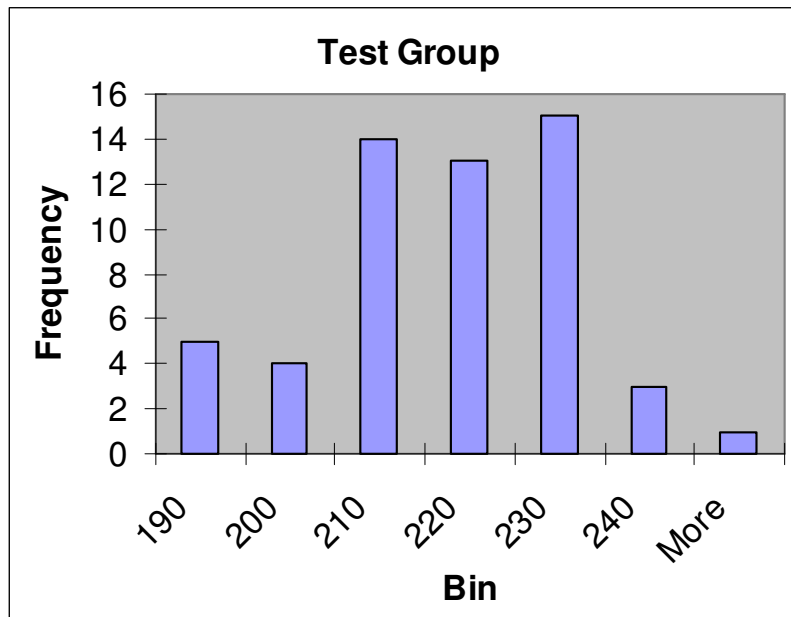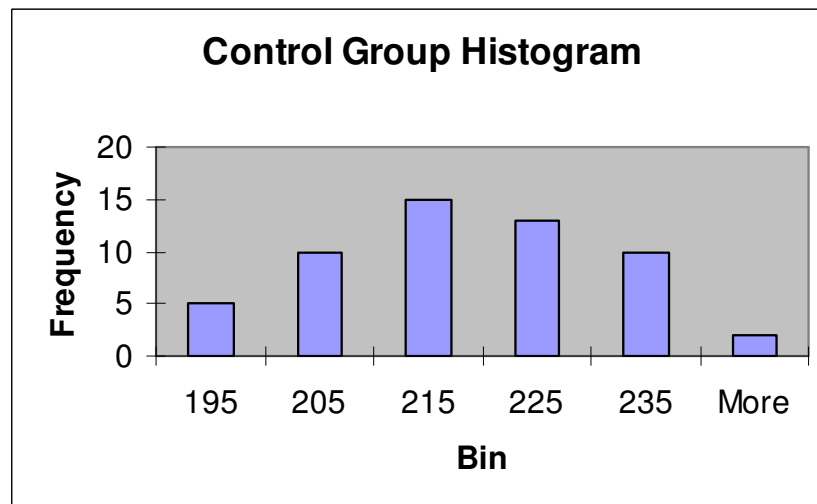|	Test	Control
Marksmen	22	20
Sharpshooters	13	15
Experts	20	20
Median	213	214
Mean	212.96	213.29
Standard Deviation	13.31	12.44
Below –s	9	10
Above +s	12	12

Table 4.   Performance Comparison for Qualification Scores

The histograms in Figure 10 and Figure 11 reveal the appearance of a slightly heavy lower tail in the test and control group. All of the subjects in both the test and control groups qualified in one of the three skill classifications during the range week. However, some of the shooters in each group failed to qualify on their initial attempt. A shooter who fails to attain the minimum qualifying score of 190 will repeat the course of fire until he attains a score of at least 190. If the shooter subsequently qualifies, a score of 190 is recorded for record regardless of the raw score achieved on the subsequent attempt. There were five subjects in the test group who failed to qualify on their initial attempt and received a record score of 190. There were two individuals in the control group for who a score of 190 was recorded but, the data sheets did not indicate whether that score was achieved on an initial or subsequent attempt.

For those two individuals in the control group for whom a score of 190 was recorded, it is possible that they

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scored a 190 on their initial attempt to qualify but it is more likely in any particular case that the subject scored less than 190 on the initial attempt and achieved a score of at least 190 on a subsequent attempt to qualify. Consequently, it can only be said with certainty that the subjects in the control group with a recorded score of 190 scored less than 191 on their first attempt to qualify. These individuals scoring less than 191 on their initial attempt contribute significantly to the heavy lower tails of the two samples.

The influence on the mean score of each sample for the individuals scoring below 191 must be examined to assess whether meaningful inferences may be drawn from the samples. Simply discarding the scores below 191 would have the obvious effect of increasing the average score and decreasing the variance of both samples. Rather than simply discarding the data points for subjects scoring less than 191 a trimmed mean was computed for each sample. For the test group the five data points in the lower tail were discarded along with the five data points in the upper tail. Likewise for the data from the control group, a trimmed mean was computed discarding the two data points in the lower and upper tails of the sample. Figure 13 and Figure 14 are histograms of the trimmed distributions of the samples from the test and control group. Similar to Figures 11 and 12, the X axis represents a partitioning of the points scored and the Y axis represents the number of subjects who tallied a score between the given partitions.

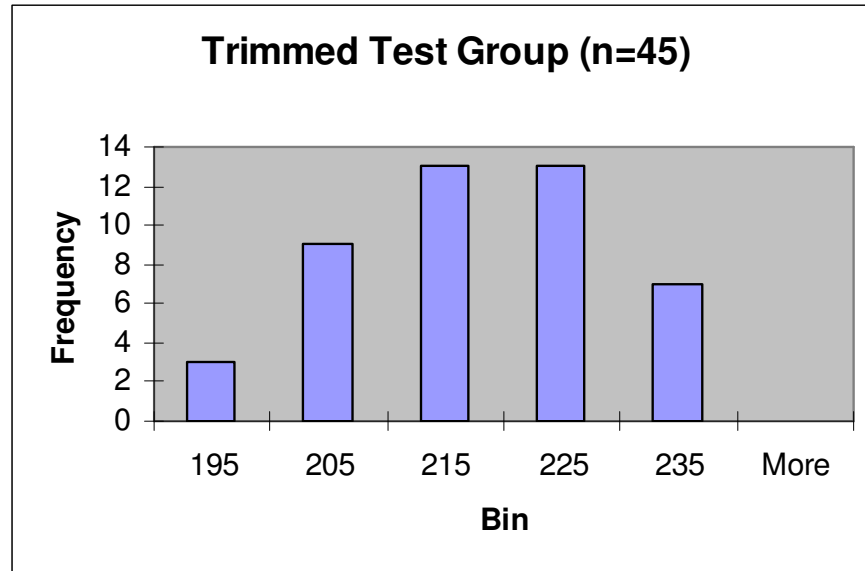Figure 13.   Distribution of Trimmed Test Group Record
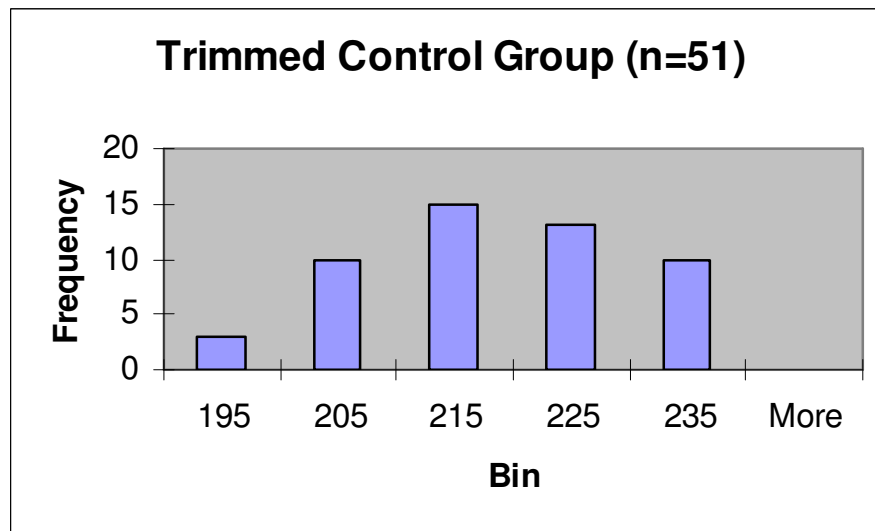Scores

Figure 14.   Distribution of Trimmed Control Group Record
Scores

A second trimmed mean was computed for the control group in which five data points from each tail were discarded in order to compare the variance with that of the sample from the trimmed data sample of the test group. Table 5 provides a comparison between the full test and

control group and the trimmed samples that discard the upper and lower tails to remove suspect data.

	Test Group	Control Group	Trimmed Test Group (n=45)	Trimmed Control Group (n=51)	Trimmed Control Group (n=45)
Mean Score	212.11	213.29	213.11	213.29	213.67
Standard Deviation	15.12	11.13	10.12	11.13	9.71

Table 5.   Means and Standard Deviations for Test and Control Group Scores

The comparison of the record score performance of the test and control groups indicates with a 95% confidence interval there is no statistical difference in the performance of those subjects who received training in the ISMT prior to live fire marksmanship training and testing for proficiency.   Thus, we fail to reject the null hypothesis that subjects trained in the ISMT do not perform better than those who are trained without exposure to the ISMT.   The lack of significant difference between the test and control groups does not assume that dry fire training during grass week, whether in the virtual environment of the ISMT or not, is a strong predictor of live fire performance.   The dry fire training is a phase in marksmanship training that links classroom instruction and live fire training that offers a chance for the student to perform many iterations of simulate practice at shooting a weapon with minimal cost in a relatively short amount of time.

The conclusion drawn from the data is the ISMT performs as well as conventional dry fire training methods may not appear to be a ringing endorsement for the ISMT's

effectiveness but it is of value because it supports the employment of the ISMT's continued use as a VET. Without controlled quantitative analysis to validate effectiveness, there exists a very real potential that a VET does more harm than good despite an appearance of face validity. The results of this experiment lend support to the ISMT's fidelity to task and permit a confident statement at an α = 0.05, 95% confidence interval that training with the ISMT does not result in negative training transfer. Recalling the inclement weather conditions under which the test group fired for qualification there is a possibility that under controlled weather conditions shooters trained on the ISMT might perform statistically better than their conventionally trained counterparts. Exploration of that possibility is not possible within the scope of this thesis.

B.   TEST OF PREDICTIVE VALUE OF SIMULATED SCORING

1.   Primer on Exterior Ballistics

A discussion of the predictive value of simulated fire scores to live fire scores should begin with an understanding of a bullet's exterior ballistics. Exterior ballistics describes the physics of the motion of a projectile moving through space. For the purposes of this research exterior ballistics will be constrained to the motion of a bullet subject to the forces of gravity and friction with the air.

Figure 15 depicts the trajectory of a bullet fired from a rifle. For purposes of discussing ballistics and trajectory consider the X axis to be perpendicular to the diagram and the Z axis corresponds to the direction of travel from the rifle to the target. There are two points

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along the trajectory at which the path of flight of the bullet intersects the line of sight of the shooter. The trajectory of the bullet is not literally a line but an arc caused by acceleration due to gravity pulling the bullet down to earth. Absent the effects of friction from the bullet passing through the air, the shape of the arc would be parabolic but in reality is skewed as the bullet loses forward velocity.
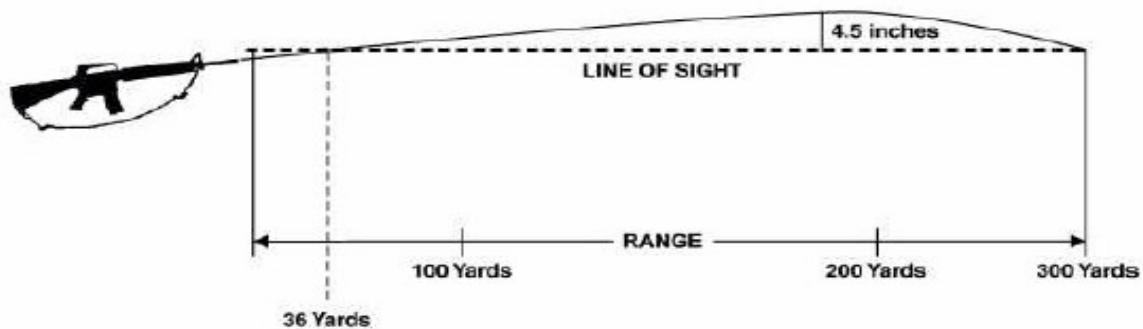
Figure 15.   Diagram of Bullet Trajectory

The first point of intersection of the trajectory and the line of sight is referred to as "near zero" because the delta between the bullet's position in the Y axis and the shooter's line of sight at that point on the trajectory is a distance of zero. The near zero is approximately 36 yards in the Z axis forward of the service rifle. Speaking generally about bullet trajectories, the near zero distance from the muzzle varies depending on the weapon and ammunition fired from it but the distance of 36 yards is applicable to the M16A2 service rifle and M855 5.56mm NATO ball ammunition for which the ISMT is modeled. The "far zero" is, for a properly adjusted and properly aimed weapon, at the point of aim on the target. When a marksman has "zeroed his rifle" at a specific range this means that he has calibrated the sights on the rifle so that the "far

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zero" of a properly aimed shot will coincide with a point of aim at the range for which it has been zeroed. Marine Corps doctrine teaches marksmen to calibrate their rifles to a zero range of 300 yards. A 300 yard zero range is referred to as the "battlesight zero" or BZO.

The rationale for calibrating all service rifles (not to include special weapons employed by snipers) to BZO follows from the knowledge that most rifle engagements take place at distances of 300 yards or less. Figure 16 shows the graph of the rise and fall of a 5.56mm M855 NATO bullet fired from a rifle with a 300 yard zero fired with the barrel level to the ground. The plot was created on September 6, 2004 using the exterior ballistic calculator software hosted on the World Wide Web by Real Guns Inc. at http://www.realguns.com/calc/exteriorballistics. The path of the bullet begins at 2.5 inches below the eye point of the shooter as this is the separation in the Y Axis between the rear sight aperture and the breech of the rifle.

In a combat situation a shooter may not have time to adjust the sight elevation to a shorter or longer range from the BZO. For such cases that the shooter fires at a target that is less than 300 yards in range, Figure 16 illustrates the limits in deviation of the point of impact from the point of aim. The maximum deviation above the point of aim is a fraction over four inches for a target that is at 150 and 200 yards range. The greatest deviation below the point of aim for a target closer than the near zero distance of 36 yards is 2.5 inches below the point of aim. Such variation in the point of impact from the point of aim is generally considered to be negligible to affecting the lethality of the bullet on its target. The

BZO calibration is therefore a "good enough" setting for most tactical shooting situations.
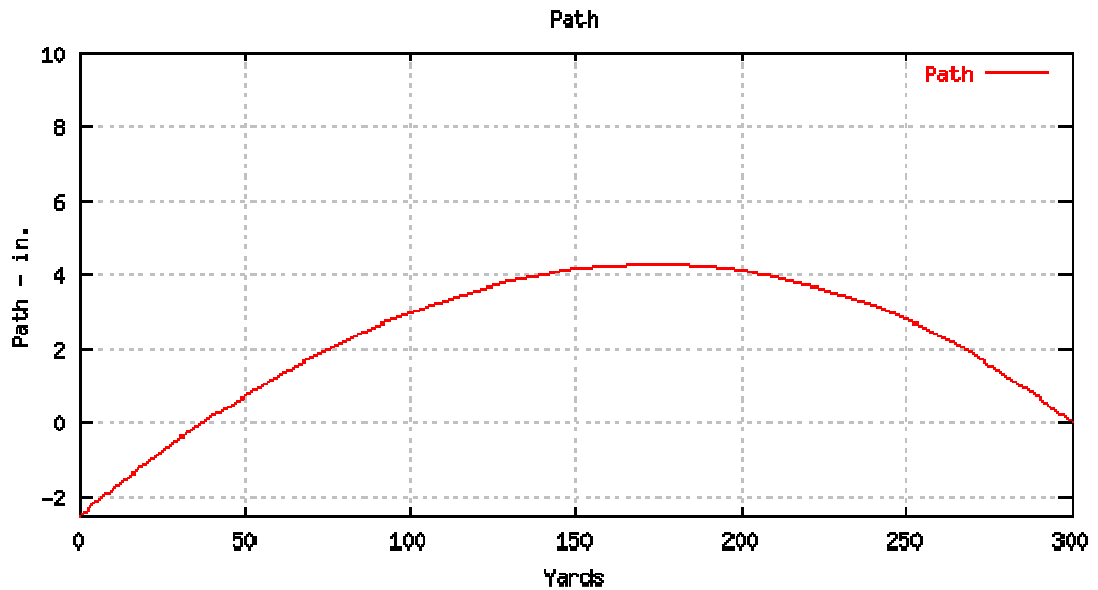
Figure 16.   Trajectory of M855 Ammunition at 300 Yard Zero

2.   Scoring Criteria

Testing for a correlation between scores for simulated fire in the ISMT and live fire requires an understanding of the criterion used to evaluate a shooter's performance. The criterion for scoring the known distance course of fire are detailed in the MCO 3574.2J, Regulations Governing Training/Evaluation with the M16A2 Service Rifle. This governing directive awards points toward qualification to shooters based on whether the impact of the round is within the black region of the target facing. That is to say that the scoring criterion is biased in favor of accuracy over precision. The ISMT uses the same scoring criterion as is used for live fire scoring.

In Figure 17 the shots in Group A would all be awarded zero points because they are outside the black circular

target region while four out of the five shots in Group B
would be awarded points for hitting the target.

Group A
(8 cm dia)
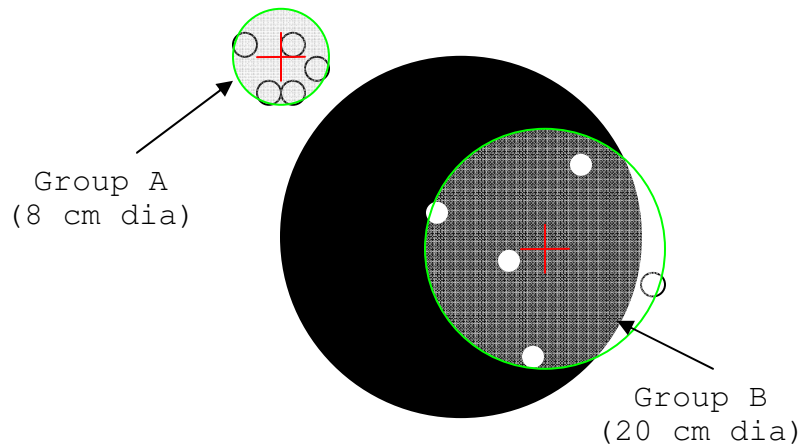
Group B
(20 cm dia)

Figure 17.   Group Precision versus Group Accuracy

The diameter of the circle drawn around Group A
indicates that the shooter has mastered the perceptual-
motor skills necessary to fire a consistent pattern at a
single point of aim although the mean point of impact for
that point of aim is outside the scoring region.   By
contrast, Group B indicates that the shooter has not
mastered the skills necessary to fire precisely and
consistently but is able to center the mean point of impact
of his shots on the target.

3.   Parsing the Meaning of an ISMT Shot Group

A small consistent shot group that impacts the
projection screen of the ISMT outside of the target region
suggests that either the shooter is aiming consistently at
the wrong location or that the ISMT is applying an offset
to the literal point of impact of the laser on the
projection screen when plotting and scoring the round.
Proper aim of the weapon is taught during the three days of

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Grass Week prior to the training in the ISMT. Proper aim results from maintaining a consistently proper sight alignment and sight picture throughout the full period from when the trigger squeeze begins until the round is fired.

Figure 18 illustrates proper sight alignment and proper sight picture for the M16A2 service rifle. Sight Alignment is defined as having the top of the front sight post centered along the X and Y axes within the view through the rear sight aperture. Sight picture refers to properly centering the front sight post to occlude the "center of mass" of the target at which the weapon is being aimed.
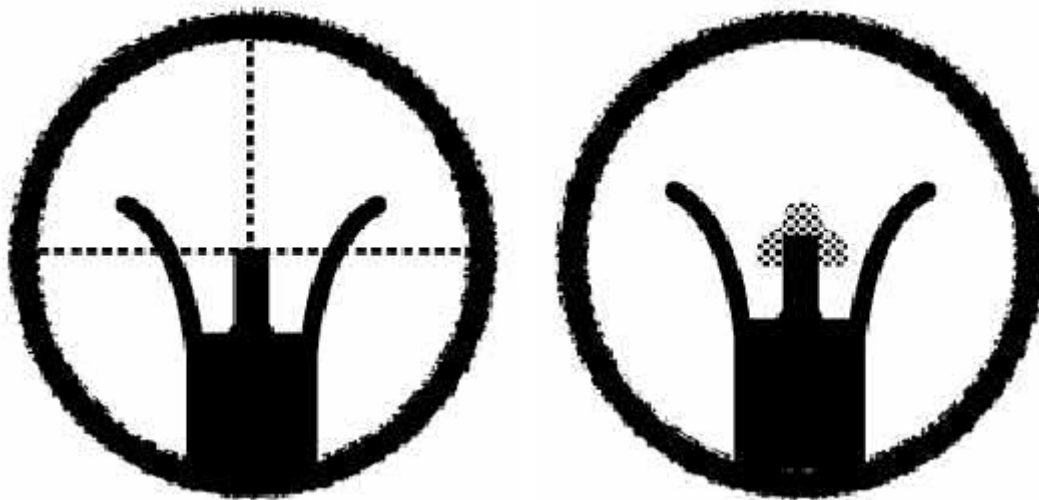
Figure 18.   Proper Sight Alignment and Sight Picture

If a shooter is maintaining proper aim with the weapon during the entire period of trigger squeeze and the shot group is outside the black scoring region it is likely that the weapon's sights are misadjusted. The simulated service rifle used in the ISMT is capable of accurately reproducing the effects of rear sight windage adjustments on the point of impact of the laser on the projection screen. The relationship between adjustment of the rear sight windage

knob and the change in the aim point is a simple linear relationship. However, the ISMT may not accurately reproduce the effects of rear sight elevation adjustments. The Operator's Manual for the ISMT does not discuss the methods employed in the software to simulate changes made to the elevation sight adjustment.

Experimentation with the ISMT in the laboratory suggests the ISMT does not contain true ballistic models of a bullet's flight path. Rather, it contains what I would refer to as a pseudo ballistic model. It is not a true ballistic model because it does not calculate the position of the simulated bullet throughout its path of travel but only at the point of impact at the target. The software in the ISMT cares nothing of the position of the bullet in flight but it does apply a standardized Y offset to the aim-point of the simulated bullet based upon the notional range of the target to determine the point of impact. This offset in the Y axis is calculated from the difference in the notional range of the target projected on the screen from 300 yards. According to the calculations using the Real Guns Inc. software, the appropriate Y offset that should be applied by the ISMT to the point of aim for a round fired from an SRS with an accurate BZO is approximately 30 inches below the point of aim. Figure 19 is a plot of the trajectory of an M855 round fired under the circumstances described.
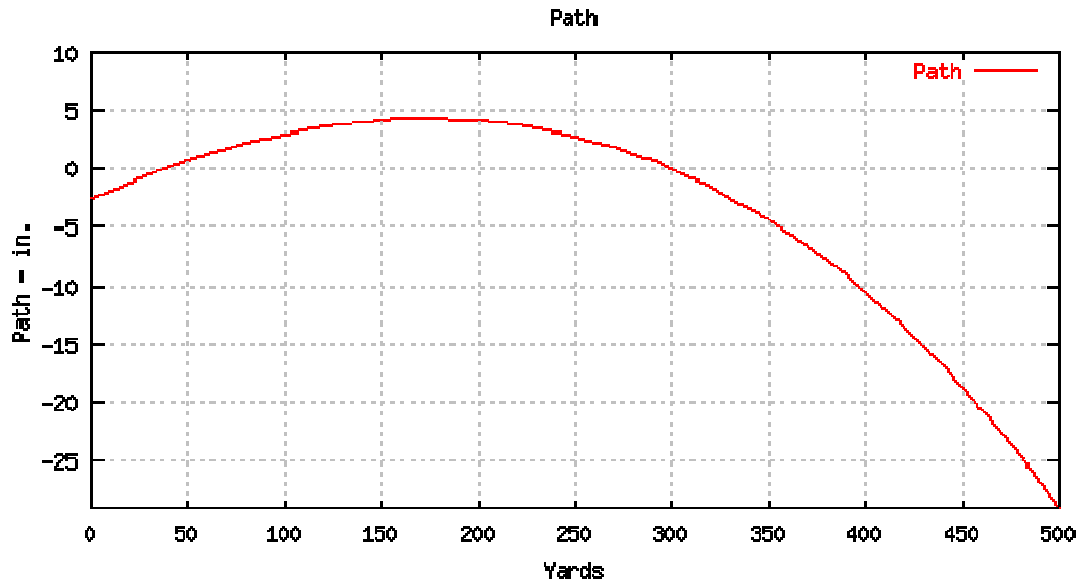
Figure 19.   Trajectory of M855 Fired with BZO at Target
                    Range of 500 Yards

From experimentation in the lab it appears that the
ISMT drops the calculated point of impact by an appropriate
magnitude for the situation described above. To move the
calculated point of impact onto the center of mass of the
target the shooter must add seven increments of elevation
to the BZO setting on the rear sight to compensate for the
drop of the bullet between 300 and 500 yards range.   If
this procedure is followed, the ISMT should faithfully
reproduce the point of impact that would result from
corresponding adjustments in sight elevation.   However, it
should be noted that the SRS has no sensor to determine
what the elevation setting is on the rear sight.   If an
adjustment to the BZO sight elevation is made that is
between zero and seven increments then the computed point
of impact will not be accurate because the ISMT is using a
linear offset to the computed point of impact instead of a
true physics based ballistic model.

The ISMT software includes a feature referred to as "auto-zero." The auto-zero function, actuated by the operator of the ISMT control station vice the shooter, computes the mean value in X and Y coordinates of a grouping of simulated shots on the projection screen and compares it to the center mass of the target (0, 0) and then applies a corresponding negative offset in the X and Y axis as a correction factor. The result is that the shooter continues to aim at the same point as before but the grouping of all subsequent simulated shots will be plotted with the negative offset. Perfect elevation and windage corrections are implemented by a keystroke without any direct input from the shooter. The use of auto-zero relieves the shooter from empirically determining and applying a correct elevation and windage setting but may be justified to achieve a proper zero on the SRS for known distance shooting.

4.   Analysis of Correlation

The correlation of the scores for subjects firing the simulated qualification course of fire to their scores on the live fire qualification course was 0.41. Thus, we reject the null hypothesis that there is no significant correlation of performance in the ISMT to live fire performance and we conclude that there is a positive correlation between simulates and live fire performance. As was previously cited, a similar study of the Weaponeer marksmanship trainer in 1985 found a correlation OF 0.44 between simulated and live fire. The architecture of the ISMT implements significantly newer technology and a more precise sensor for hit detection that the Weaponeer so it seems at first glance that the correlation should be higher than a trainer built with the older technology.

The data collected from the subjects firing the simulated course of fire is only the numerical score and did not include a record of the grouping diameters or the shot patterns. Diameters and graphical plots of the shot groups for each subject would have provided useful insight on what elements of marksmanship were present or lacking in the subjects but were not considered in the design of the experiment prior to data collection. In the absence of graphical information on the performance of the subjects I examined comments written by the PMI on the scoring sheets for the simulated course of fire. These comments provide some clues as to why the correlation between simulated and live fire was not higher.

Of the 36 subjects who fired the simulated course of fire for score, the PMI made brief written comments on the data sheet regarding the characteristics of the shooter's performance. Most of the comments refer in some way to the subject's ability to "group" shots (referring to precision) and also on the consistency of the shooter's "zero" (the accuracy of the mean point of impact of a group). There were 12 instances in which the PMI made comments that the subject had "good" or "decent" groups but inconsistent or floating zeros. In ten of these twelve cases where the subject's precision on the ISMT was assessed to be "good" or "decent" and yet had poor consistency the subject scored above the mean score for the test group. The remaining two subjects scored within two points of the mean.

Appendix C. contains a table of the 36 subjects who fired both simulated and live courses of fire in ascending order by their score on the live fire course. The table also includes the score for the simulated course of fire

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along and a transcription of any comments made by the PMI on the score sheet for the simulated course of fire. Reading the comments of the PMI and comparing those comments with a subject's score on the simulated and live fire suggests that the ISMT may be more effective at training shooters to increase their precision than it is at adjusting the accuracy of their shot groups. The apparent weakness at teaching shooters to adjust their accuracy may be related to the way that the ISMT treats incremental adjustments to sight elevation but is probably also a reflection of the training procedures used during the experiment.

A BZO calibration for a particular rifle or SRS will vary depending on who is shooting the weapon. The distance of eye relief and variations in individual shooting position can influence the BZO calibration from on shooter to the next. In the protocol exercised during this experiment, it is doubtful whether there was sufficient time in the training schedule for each shooter to determine and confirm an accurate BZO for the SRS used to fire the simulated course of fire. The subjects were randomly assigned to one of 18 SRS stations and may not have fired for score on the same SRS that they had used for practice the previous day. By contrast, the subjects had had three days of live fire training on their individually assigned weapon in which to determine and confirm an accurate BZO. The familiarity with their individual weapons that the subjects attained during the live fire training prior to qualification intuitively supports the idea that they would score higher on live fire training than on the ISMT.

When reviewing the design of the experiment after the data had been collected, it became apparent that the comparison of the ISMT scores with live fire scores from the last day of live fire training on the known distance course of fire was not the most valid comparison for skills transfer. Between that simulated course of fire on a Friday afternoon and their final qualifying live fire course, the subjects had four more iterations of live training during which I believe they learned and improved significantly. The training and skills that were refined on Monday, Tuesday, and Wednesday of Range Week probably reduces the correlation of the dry fire training on the previous Friday. A better comparison would be to shoot in the ISMT on the day immediately after firing for record on the range or a pseudo training transfer study in which the subjects fired in the ISMT, on the range, and then again on the ISMT on three successive days.

C.   ANALYSIS OF THE INFLUENCE OF PRACTICE ON PERFORMANCE IN THE ISMT

Twenty-eight subjects participated in at least one trial of data collection for the grouping experiment. I selected a threshold of six complete trials as the minimum amount of data on a subject to be considered in the analysis of the experiment. The performance trends that are compared in this experiment are all based on linear regression models calculated from six or more data points. The regression models for each subject use the independent variable of the number of practice trials as the predictor of the dependent variable of the diameter of a shot grouping.

The linear fit models calculated for the thirteen subjects who fired at least six trials showed a wide range

of variability in the slope. Thus, we fail to reject the null hypothesis that practice using the ISMT does not produce a uniform trend of improvement and we conclude that performance trends include cases of improvement, no improvement, and degradation with practice over the number of trials conducted in the experiment. Figure 20 is an overlay of the performance trend lines for the twelve subjects who completed at least seven trials.
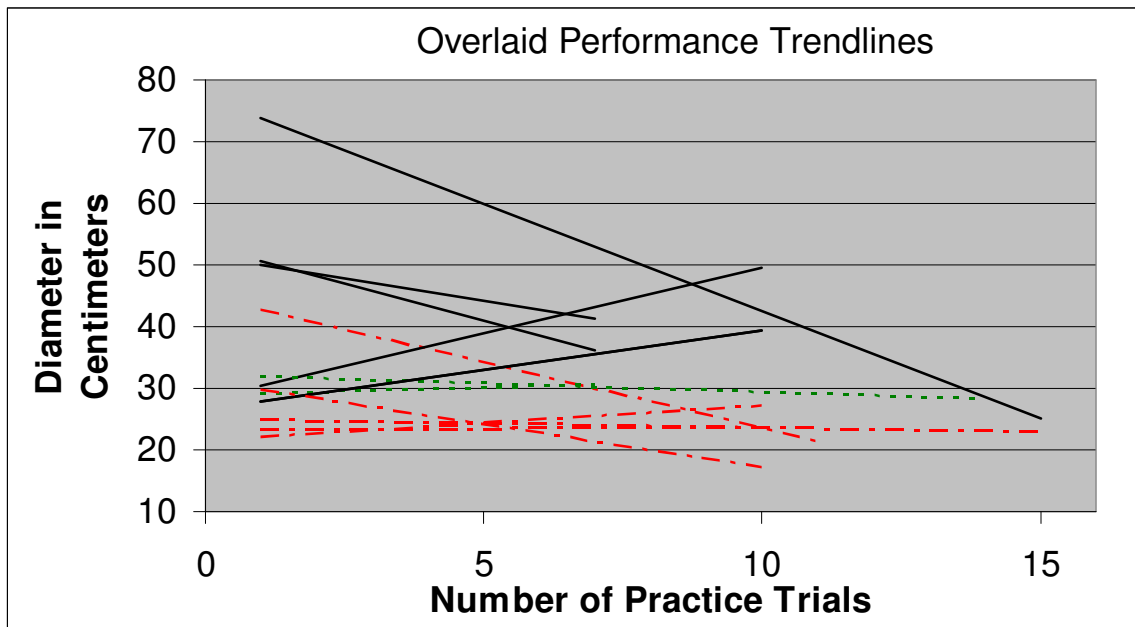
Figure 20.   Performance Trend Lines for Shot Group
Diameter

For purposes of analysis, the twelve subjects were divided into two groups based upon whether that had received formal service specific training on rifle marksmanship. The group classified as not having received formal marksmanship training, referred to hereafter as the untrained, was comprised of two civilians, three United States Navy Officers, and one Bahraini Air Force Officer. The group classified as having received formal marksmanship training, referred to hereafter as the trained, was

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comprised of five United States Marine Corps officers and two United States Army infantry officers. None of the trained subjects had fired either a rifle or in the ISMT for at least one year prior to participating in this experiment as a result of being assigned as student personnel at the Naval Postgraduate School. In Figure 20 the untrained subjects are represented by solid trend lines and the trained subjects are represented by dashed lines.

Subject 1 was a special case among the sample population. Based on his service as a Surface Warfare Officer in the U. S. Navy and never having served in a capacity requiring periodic training and qualification with a rifle I placed him in the group designated as the untrained. As I reviewed the performance of the untrained subjects as a group, Subject 1 stood out because of his dramatic improvement over the course of 15 trials. As indicated in Appendix B, the first trial fired by Subject 1 was among the largest diameters (lowest precision) for any trial by any of the subjects. However, by his 15th trial Subject one had steadily shown improvement to the point that his group diameters were in the same range as the performance of the trained subjects.

In an attempt to understand why Subject 1 improved steadily in a manner that was inconsistent with the other four untrained subjects, I inquired as to whether he had ever received formal training in marksmanship. Subject 1 stated that some eight years previous to the experiment he had received basic instruction in marksmanship when he was briefly affiliated with the United States Naval Academy shooting team while a Midshipman at the school. After brief participation on the shooting team, Subject 1 did not

fire a rifle again on a scored course. This prior training received by Subject 1 makes it debatable as to whether he should be classified among the trained or the untrained subject. Broad generalizations should not be drawn from the performance of a single individual but the case of Subject 1 suggests that a basic knowledge of marksmanship offer benefits in recovering lost proficiency even after many years of atrophy.

There is an obvious qualitative difference between the proficiency of the trained subjects compared to the untrained subjects. Subjects with formal training and knowledge of marksmanship techniques demonstrated smaller shot group diameters on average than did subjects without formal training even after several repetitions of practice in the ISMT. Figure 21 compares the average shot group diameters for the first trial, last trial, and all trials. The results are divided into trained, untrained and combined population.
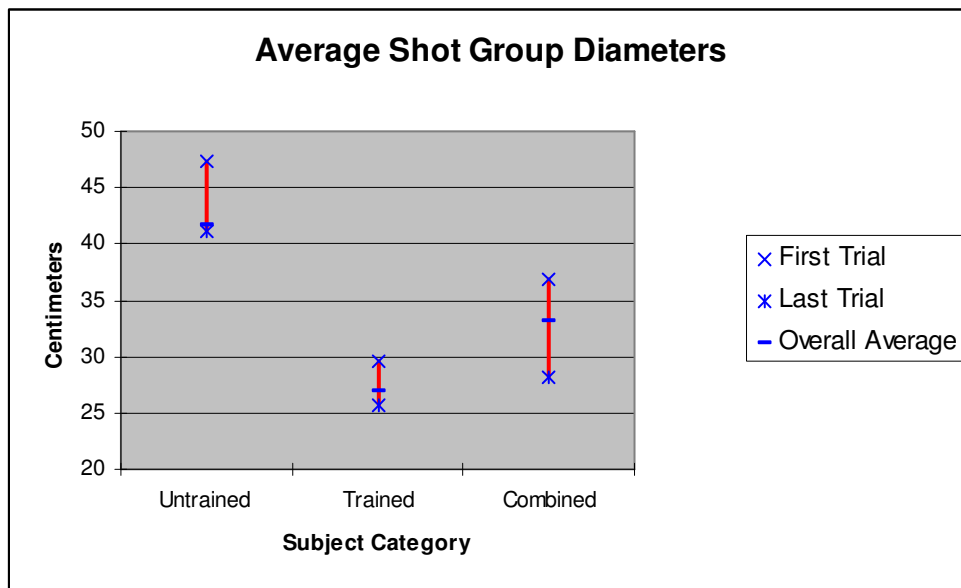

Figure 21.   Comparison of Average Shot Group Diameters

It is tempting to infer too much from the results of this experiment that cannot be supported by the data. Keeping that in mind, I do believe that some general inferences may be made about the training value of the ISMT. The ISMT appears to provide a useful tool as a sustainment trainer for individuals who already possess knowledge of marksmanship techniques gained through formal training.

The ISMT does not display the results that would be expected of a black box trainer. That is, repetitive practice in the ISMT without coaching does not produce steady improvement from untrained subjects. The comparisons between trained and untrained shooters who are afforded similar amounts of practice leads to the conclusion that trained shooter retain proficiency from previous experience and can make steady improvement in small increments.

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VI. RECOMMENDATIONS

A. EMPLOYMENT OF THE ISMT

1. Initial Entry Training

The statistical analysis of the performance does not suggest that training recruits through practice in the ISMT should be emphasized over conventional dry fire methods. Without dismissing the possibility that practicing in the ISMT immediately before qualification might have a positive effect, the three days of live fire practice following the test group's exposure to the ISMT was enough to mask any initial advantage imparted to the test group by ISMT training. By the same token, the data does not provide any hint that use of the ISMT in training initial entry recruits should be curtailed. The ISMT is a complementary tool for teaching known distance marksmanship to novice shooters. Recognizing that variety in training media generally tends to increase a student's interest and engagement in learning, the ISMT offers the added dimension of performance feedback.

Prior to the collection of data from the experiment with recruits at Edson Range the chief range officer expressed his view that the ISMT was most effective as a tool for the marksmanship instructor to analyze the performance of shooters who are having difficulty in meeting qualification standards on the live fire ranges. His preferred method of employment for the ISMT was for a PMI to provide remedial practice and coaching to shooters who were having difficulty mastering the fundamentals of marksmanship. When used for focused remediation the ISMT

provides detailed feedback to the PMI that is a useful analysis tool in teaching novice shooters to master the basics.

2.   Sustainment Training

The data collected in the grouping experiment leads to three recommendations on employing the ISMT as a tool for sustainment training. Firstly, practicing the ITS training events in the ISMT repetitively does not lead to significantly improved precision without an existing knowledge of marksmanship techniques. The data did not provide statistical support for the assertion that practice in the ISMT imparts skill to un-coached novice shooters.

Effective training in known distance marksmanship using the ISMT requires that the trainee has mastered the fundamental techniques of marksmanship or that a qualified PMI be present to provide instruction. The ISMT lane training is primarily composed of perceptual-motor tasks. These perceptual motor tasks require not only consistency and precision but also a cognitive understanding of cause and effect for numerous elements of the task. Without understanding the necessity of proper and consistent skeletal support of the rifle, eye relief, breathing control, trigger squeeze, sight alignment, sight alignment, and sight picture the trainee will not reap the full benefit of the ISMT's virtual training environment.

Marksmanship training in the ISMT should always begin with a focus on the precision before attempting to train for accuracy. Just as with live fire training a three shot group with a mean point of impact precisely at the center of mass of the target is useless if the diameter of that group is 40 centimeters across. Plenty of time should be

allocated to achieving a consistently small tight shot group in the ISMT before moving on to scored training events. The ISMT provides an useful tool for sustainment training focused on precision. The efficiency (quick scoring and feedback) and nearly negligible cost of firing simulated ammunition in the ISMT maximize training resources before the expense of firing live ammunition to refine the size of a shooter's shot group before commencing the training events that are scored for accuracy.

Using the ISMT to train shooters in adjusting the accuracy of their shot groups should be done with the understanding that the ISMT is designed to accurately replicate the effects of *doctrinal* adjustments to sight elevation. The pseudo ballistic models used by the ISMT to determine the drop of a bullet caused by gravity must be compensated with *doctrinal* adjustments to sight elevation. For the known distance events in the ISMT achieving an accurate BZO is of paramount importance when training for accuracy. The calculated point of impact for rounds fired at targets at notional ranges of 200 and 500 yards depends on an accurate calibration of the BZO and making the appropriate decrease or increase in sight elevation.

B. FUTURE RESEARCH

1. Pseudo Training Transfer Study

A pseudo training transfer study would be useful to confirm and expand upon the experiment conducted with initial entry recruits at Camp Pendleton. The subjects should be screened on the simulated course of fire immediately before firing the live fire course and screened again after the live fire course.

Such a study would begin with screening qualified shooters on the ISMT immediately prior to firing a scored live fire course. The effects of three days of live fire training which transpired between the scoring of simulated fire in the ISMT at scoring of record fire probably weakens the correlation between the simulated and live fire scores.

Already qualified shooters would be a more relevant population to study for data pertaining to the value of the ISMT as a sustainment trainer. Shooters who are already close to the asymptote of their learning curve as marksmen might display a much stronger correlation in scores from simulated fire to live fire.

Marine Reservists preparing for their annual rifle marksmanship requalification might provide and ideal population from which such a sample for a pseudo training transfer study. Reservists typically qualify on a compressed training schedule of less than a week on the live fire range. Additionally, there are 265 ISMT units fielded throughout Marine Forces Reserve.

Future studies comparing the performance of shooters firing in the ISMT and on the live fire course of fire should place a premium on controlling for inclement weather. The strength of the data in this thesis gathered from the test group of recruits at Edson Range was diminished by the confounding effects of weather.

2. ISMT Recorded Video and Judgment Shooting

This research did not explore the validity of the ISMT as a trainer for judgment in tactical situations. The Marine Corps has expanded the number of individual training standards which are required to be trained in the ISMT.

Many of those training events involve operations in a tactical environment that is not closely replicated by the ISMT.

The cognitive task analysis of many ITS contain steps that are in no way replicated by the ISMT virtual environment. The ISMT is an arcade scenario VET in which the trainee does not have to supply locomotion through the environment (either on foot or by vehicle). Trainees are absolved of the concern of seeking cover and concealment when training in the ISMT nor are they concerned with the enemy ascertaining their locations based on the sounds generated from the noise of their weapons. Consequently, it seems likely that the ISMT might reinforce the tendency for trainees to be overbold in how they react to a tactical situation if the ISMT is the only analog they have experienced. The overlap of the domain of the ISMT environment and actual tactical situations might be considerably smaller than the overlap for known distance marksmanship.

Tactical
Environment

ISMT
Training

−Concealment
−Cover
−Noise Discipline
−Seeking Better
 Fields Of Fire
−Fatigue

−Decide
to Engage
Targets

−Keep
Attention
Fixed on
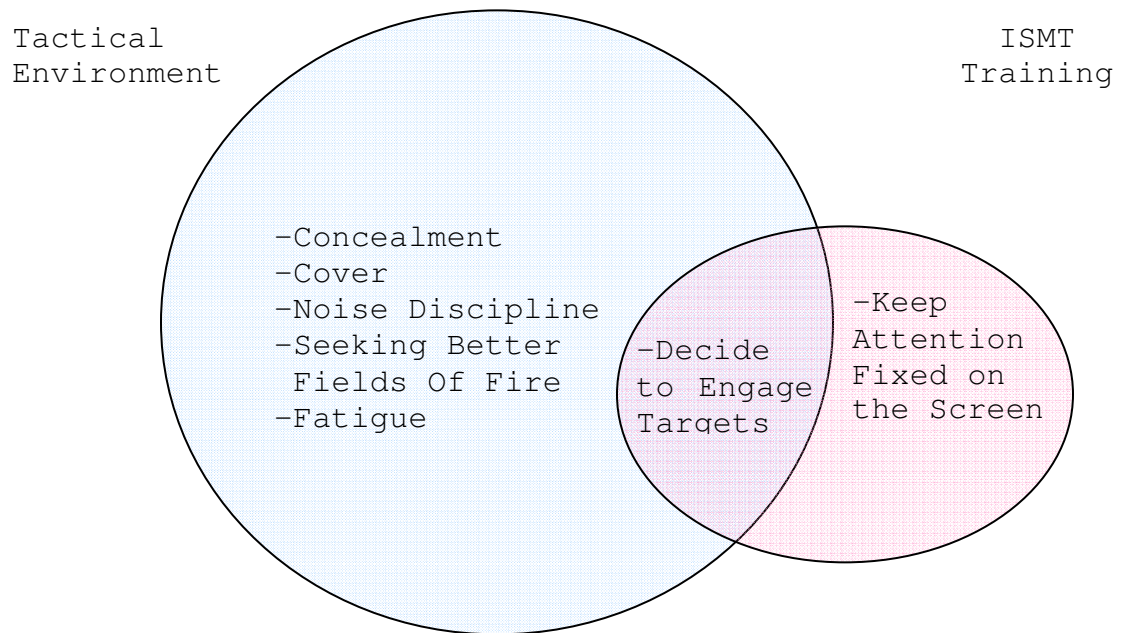the Screen

Figure 22.   Potential Overlap in ISMT Video Training
                        and Tactical Situation

        Reviewing the ITS manual for infantry tasks provides
an example of a task that appears to be outside the
capabilities of the ISMT's physical design. The ISMT is
required to provide training for ITS 0331.01.09: *Engage and
Air Target with a Machinegun.*   The administrative
instructions for this ITS state the task will be conducted
in the ISMT *in lieu of live fire training.* The obvious
physical limitation of the ISMT in accomplishing this task
is that it is only capable of projecting a video image with
a 19 degree field of view from the bottom to the top of the
screen. The limitation imposed by a 19 degree vertical
field of view means a trainee cannot elevate his simulated
weapon high enough to engage targets which would be flying
over head with a rapidly changing angle of elevation. The
ISMT is able to employ algorithms to effectively simulate
the need for a gunner to lead a fast moving target, but the

flat projection screen prevents the more difficult element of the task, which is aiming the weapon at a high angle while tracking the target.

3. Integration of Perceptual—Motor Training with Cognitive Instruction

Research by Dr. William Bewley at the UCLA Center for Research on Evaluation, Standards, and Student Testing (CRESST) sponsored by the Office of Naval Research (ONR) has approached the problem of improving Marine Corps marksmanship proficiency from the perspective of cognitive training. Dr. Bewley's project addressed questions of what knowledge is critical to shooting performance, to what extent can cognitive assessments predict shooting performance, and what cognitively based measures can be used to provide effective remediation (Bewley, 2004).

The possibility of combining the perceptual—motor training provided in the ISMT with the knowledge based training developed at CRESST merits additional research. One approach for combining the cognitive and perceptual—motor training would be to use a shooter's performance on the ISMT as an input for providing appropriate knowledge based training to assist in correcting bad shooting habits. The knowledge based training could be interspersed throughout ISMT training events and be displayed on the projection screen of the ISMT.

Since the ISMT already incorporates a laser sensing hit-camera the subjects being trained on the ISMT might be able to use a laser pointing device to facilitate input to the knowledge based assessment and training vignettes. A laser pointer could be employed to select a response to multiple choice questions displayed on the screen and then

to confirm (enter) the selection.   The integration of knowledge based training with the ISMT's existing capabilities would be primarily in development of software since the hardware interface would apparently need little modification because of the existing laser sensor.

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APPENDIX A. SUBJECT QUESTIONNAIRE
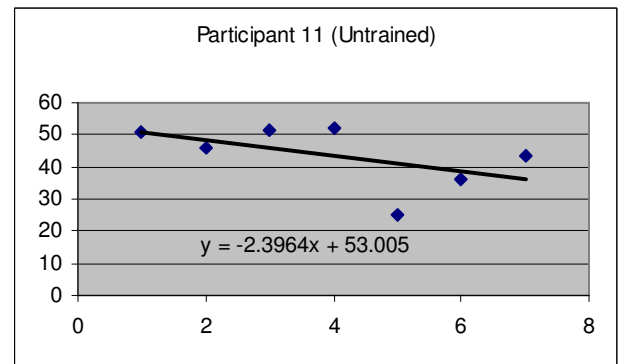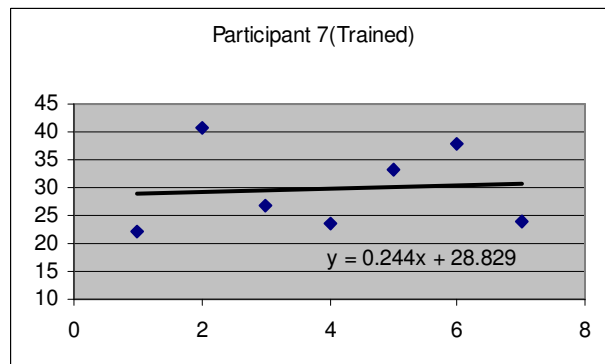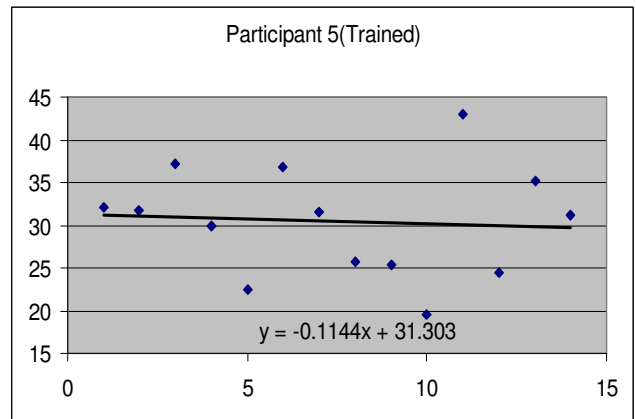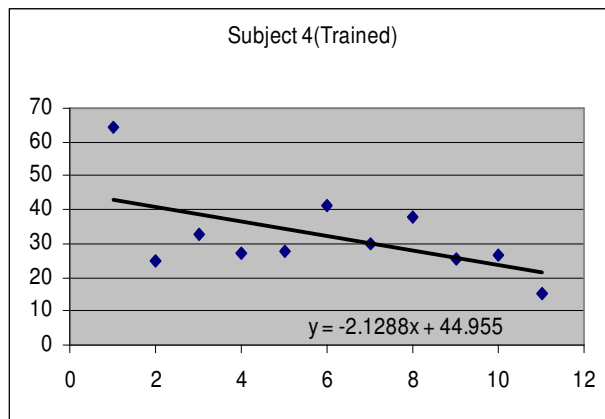

<u>Questionnaire</u>

<u>NAME</u>_____

<u>SSN:</u>_____

1. Date of Birth_____
2. Sex _<u>M</u>_
3.   Do you wear corrective lenses (glasses or contact lenses)?
4. Height_____
5. Weight_____
6. Do you have normal color vision (not colorblind)? Yes No
7. In the course of a normal training day during boot camp do you consume any coffee or other sources of caffeine? Yes   No
8. If you answered yes to question 7, how many cups on average?____
9. Have you ever fired a rifle? Yes No
10. If you answered yes to question 9, describe how often and how recently you have fired a weapon._____
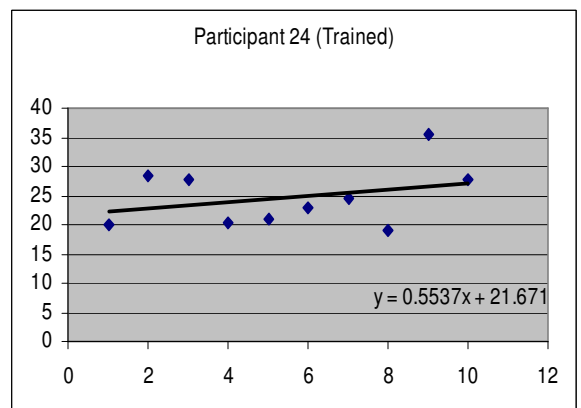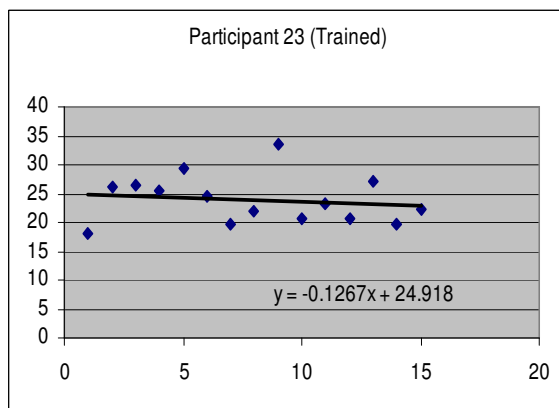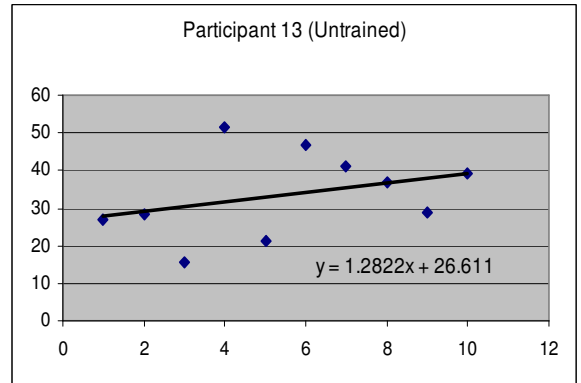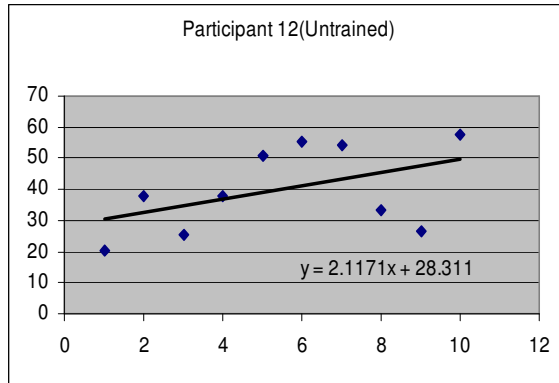11. If you have experience using a rifle, have you received any formal training in marksmanship prior to arriving at boot camp (NRA, ROTC, or marksmanship training in another branch of the military). Yes   No
12. Have you ever fired a rifle on a scored course of fire? Yes No
13. Circle the description below of how you would characterize your proficiency as a marksman right now (before training as a recruit).
a. No experience
b. Some experience but a poor marksman
c. Proficient marksman
d. Very proficient marksman
14. Circle the highest educational credential that you have attained.
     GED or certificate
     High School Diploma
     Some College
     Bachelors Degree
     Postgraduate Degree

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APPENDIX B. GROUPING TRIAL MEAN DIAMETERS BY SUBJECT

Subject 1 (Untrained)

$y = -3.4831x + 77.414$

Subject 2 (Untrained)

$y = -1.4667x + 51.476$

Subject 4 (Trained)

$y = -2.1288x + 44.955$

Participant 5 (Trained)

$y = -0.1144x + 31.303$

Participant 7 (Trained)

$y = 0.244x + 28.829$

Participant 11 (Untrained)

$y = -2.3964x + 53.005$

85

Participant 12(Untrained)

$y = 2.1171x + 28.311$

Participant 13 (Untrained)

$y = 1.2822x + 26.611$

Participant 23 (Trained)

$y = -0.1267x + 24.918$

Participant 24 (Trained)

$y = 0.5537x + 21.671$

Participant 27 (Trained)

$y = -1.3895x + 31.116$

Participant 28 (Trained)

$y = 0.0279x + 23.407$

APPENDIX C. SCORES FOR LIVE AND SIMULATED FIRE
WITH INSTRUCTOR'S MARGINAL COMMENTS

Live	Sim.	Delta	Primary Marksmanship Instructor's Comments
194	152	42	
194	186	8	
201	212	−11	Good Groups, Consistent Shooter
204	122	82	Inconsistent Shooter
204	126	78	Inconsistent Shooter
205	122	83	Inconsistent Shooter
205	167	38	Decent Groups, Inconsistent at Times
206	195	11	Decent Groups, No Adjustments Made to Sight
207	209	−2	Good Groups, No sight adjustment made
207	175	32	Good Groups, Sight Adjustments Made
210	152	58	
211	203	8	Decent Groups, Consistently Low Left
212	158	54	Good Groups, No Consistent Zero
213	202	11	Consistently grouping, inconsistent zeroes
214	163	51	Good overall groups, zeroes changing up and down
216	175	41	Good Groups, Tried to Make Sight Adjustments But Couldn't "Feel the Clicks"
217	205	12	
217	121	96	
218	161	57	Groups Consistent @ 3:00
218	189	29	Zeros Inconsistent, Decent Groups
221	160	61	Loose Groups, inconsistent shooter
221	211	10	Good Consistent Groups
221	174	47	Good Groups, no sight adjustment made
223	162	61	
223	202	21	Good Groups, Inconsistent Zeros
224	190	34	
226	196	30	Floating Sights, Good Groups
227	161	66	Decent Groups, Shooter Unsure of Zeros
227	192	35	Inconsistent During Certain Strings of Fire
228	199	29	
228	202	26	Good Groups, Zeros Up and Down
229	190	39	Good Groups, Zero Changed Consistently
229	188	41	Decent Groups, Zero Changes
233	215	18	Good Groups, Consistent Zero
234	214	20	Good Groups, Sight Adjustments to Zero
236	204	32	Consistently Grouping High
241	207	34	Good Groups, Consistent Zero

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